ELECTRONIC INDUSTRIES

Including INDUSTRIAL ELECTRONICS

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The Underpaid Engineer

That radio and electronic engineers need a new yardstick for computing their own compensations, in comparison with salesmen, lawyers, and other executives in their organizations, is pretty evident to most readers of Electronic Industries. The following survey of a Cornell University class, made ten years after graduation, reveals average incomes which certainly are not representative of the relative services to the employing company or to the community and public. Surely something ought to be done to bring engineers' compensation up to levels corresponding to the true value of engineers' contributions of ideas and services.

Bankers and Brokers	$11,040	Newspapermen	$5,180
Manufacturers	8,524	Accountants and Statisticians	5,004
Physicians	7,944	Insurance men	4,533
Architects	7,230	Farmers	4,461
Merchants	7,136	Contractors	4,287
Lawyers	5,905	Engineers	3,724
Salesmen	5,690	Teachers	3,137
Purchasing Agents	5,600		

Incentive Compensation Plans

To give proper rewards to electronic engineers who make important contributions to the earnings of their corporations, Dr. J. A. Stobbe presents some interesting proposals in an article in this issue. For, not only should the radio and electronic technician benefit in a real way from the inventions and ideas which he originates, but he should also share proportionately in the general prosperity of his company, as it earns substantial sums for other executives and for the stockholders. In too few instances, so far, has the electronic engineer received his fair share of the peaches-and-cream.

Be Wise: Standardize

Everyone agrees that tube, component and equipment standardization has served a great purpose in insuring adequate production of the electronic material of war.

The future of peacetime electron-tube applications to industrial processes may very well depend on this availability of "packaged goods." The manufacturer who intends to make motor control equipment, weld-timers, photoelectric units, or almost any other type of industrial electronic device, designed for flexibility of application, should standardize, then let production roll. Only in this way can costs be cut and reliability and ease of maintenance be upped to the point where prospects generally can't afford NOT to employ electronic processing devices.

Sauce for the Gander

The shoemakers' children go barefoot, and M.D.'s die young from neglecting their health, but you'd think that the cold light of costs and profits would induce manufacturers of electronic equipment to use electronic equipment on their own production lines. We've been quite surprised to see how many tube structures are welded without benefit of tube-controlled welding time, or how much gas and I^2R electricity go up in smoke and wasted heat, brazing and soldering electronic components that could be put through in a tenth the time with electronic induction heating. How come? Aren't outsiders going to be suspicious of the golden claims for tubes in industry if they get wind of this preposterous situation? Let's be our own best customers now, thus modernizing our production facilities for that hoped for post-war business.

ENGINEERING DIRECTORY NUMBER in December

At the moment when manufacturers are announcing their new peace-time products and completing 1946 design and marketing plans, the publishers of Electronic Industries announce the Engineering Directory to be published in December as an integral part of the regular magazine. This Directory—an editorial service for the benefit of our engineering readers—will include complete listings of all manufacturers of finished products, raw materials, parts and components, equipment and accessories, laboratory apparatus and production equipment.

Be sure to return your questionnaire to editors of Electronic Industries, 480 Lexington Ave., New York 17, N. Y.

STRAIN ANALYZING AND

By CLAUDE M. HATHAWAY,
Hathaway Instrument Co., Denver, Col.

Practical schemes developed include inductance and resistance type gages with results recorded on moving film

• Engineers today are faced with the problems of designing for higher speeds and lighter weight, requiring a closer knowledge of actual strains and much more careful attention to vibration. In many modern structures, the strain introduced by vibration may be many times the static strain, and the only practical way to determine this predominant vibratory motion is to measure it under operating conditions in an actual machine. Instruments to measure strain in this manner have been of inestimable value to aeronautical engineers during the rapid aircraft development of the last five years, and these methods will, no doubt, prove to be of almost equal value in the post-war development era.

Part of the modern concept of industrial design is to know accurately the stresses applied to each part and where on the part the greatest strains occur. In very many cases mathematical or graphical analysis of strains is difficult or impossible. This formerly necessitated the inclusion of large safety factors to cover ignorance. Even then safety was doubtful, parts became bulky and costs rose. An exact knowledge of strains has produced notable improvements in military equipment designs, and will do the same for many more peace time products where economy and efficiency are both to be considered.—The Editors.

Dynamic strain recording and analysis as an aid and adjunct to engineering development and design was probably first applied on a major scale jointly by the Pennsylvania Railroad, the General Electric Co. and the Westinghouse Electric Corp. in 1935. This was in connection with development of electric locomotives, and their application to the electrified Pennsylvania system. Electric strain gages connected to remote oscillographs recorded pressures on rails, rail joint bars, and locomotive parts at various speeds, up to 100 miles per hour and over.

The dynamic strains and impacts determined by this analysis led to rapid advances in electric locomotive design, and provided valuable information on stresses encountered in rails and joint bars. The valuable results obtained led to the application of strain recording to aircraft propellers and engine mounts, and then to all other stressed parts in airplanes, so that at the present time dynamic strain recording is one of the necessities of the aircraft designer.

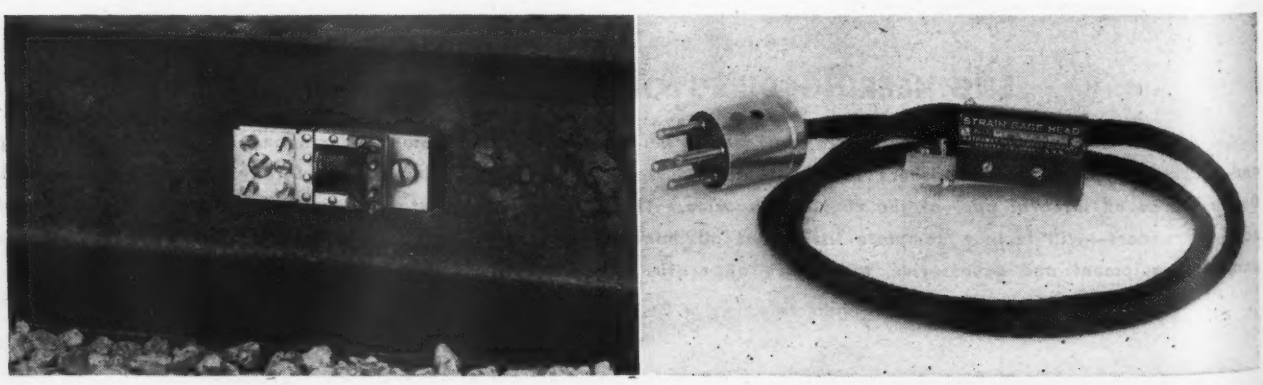
The methods of strain recording proved particularly important in this field because of the greatly increased necessity of weight reduction and the economic use of materials, as well as of the fact that failures must be held to an absolute minimum. Vibratory strains are also of particular importance in this field because of high speeds and accelerations, and all of these factors together make accurate strain measurement a prime necessity.

The many applications of electric strain gages that have been made, and the many more applications that can and will be made, will not be discussed here, except to say that almost without exception, strain gages can be applied to any stressed member regardless of size, regardless of the material, regardless of the value of the strain, and regardless of the frequency range of the strain if it is not steady. This fact, together with the obvious fact that strain is everywhere and is an underlying factor affecting the design of every machine part or device, is enough to convince everyone of the basic importance and absolute necessity of dynamic strain measurement. With this introduction to the subject and evaluation of its importance to modern engineering, we will proceed to a discussion of the instruments and equipment involved.

Apparatus needed

Electric strain-recording equipment consists of the strain gages which are attached to the member in which strain is to be measured, amplifiers for amplifying the strain gage outputs, and a recording instrument, usually a multi-element oscillograph, for recording the amplifier outputs. In some instances,

Fig. 1. Inductance type strain gage applied to a rail. As this must be screwed in place it is most used on large pieces. This gage measures strain at a point slightly off the surface thus permitting errors due to bending. This fault is not present in the type shown in Fig. 2, right



RECORDING INSTRUMENTS

the strain gage output is sufficiently high and the recording instrument sufficiently sensitive so that the amplifier is not required.

Supplementary to this fundamental equipment are the sources of electrical energy for operation of the equipment. Frequently, the primary source of electric power does not supply the right kind of power so that a special power-supply unit is required which operates from the primary source of power and supplies electric power suitable for the strain recording equipment in regard to voltage, frequency, regulation, etc.

Strain gages

An electric strain gage is an electrical device that is attached to the member at the point to be studied. Variations in electrical properties of the strain gage, as a result of strain in the member to which it is attached, are translated in deflections of the measuring instrument or oscillograph galvanometer.

Strain gages have been built involving capacitance change, inductance change, and resistance change. Gages involving capacitance change are seldom used because of the relatively greater difficulties in measuring the change, and this discussion will, therefore, be limited to gages involving inductance and resistance change.

Inductance-type strain gages

Strain gages involving inductance change have been used over a considerable period of time with very satisfactory results, and are still in considerable use, particularly on large members such as bridge members and railroad rails.

This type of strain gage has a laminated magnetic circuit in which a small air gap is introduced, and the gage is attached to the member in such a way that the air gap varies with strain. Variations in the air gap cause variations in the inductance of a coil wound around some portion of the laminated structure, and the deflection of the measuring or recording equipment is made to depend upon the inductance of the coil.

A typical inductance-type strain gage is shown in Fig. 1. The laminated magnetic circuit is made up of two parts, an E-shaped assembly and a straight bar which completes the circuit. The coil is wound around the center leg of the E, and the entire E assembly and coil is mounted on a rigid base and attached to the member under test by means of a single screw. The bar assembly or armature is likewise attached to a rigid base and to the member under test by means of a screw. Strain in the member between the two screws will produce a variation in the air gap between the two assemblies and hence variations in the inductance of the coil.

Dimensions

The strain gage shown in Fig. 1 has a gage length of two inches, which is the distance between the two mounting screws, and a weight of 4½ oz. This gage can be used satisfactorily on large members, but cannot, of course, be used on small members where the gage weight is of significance or where it would not be practical to attach the gage by means of screws. On large members where the gage shown in Fig. 1 can be used, it has certain advantages over other types, however, and these are extreme ruggedness and simplicity and the fact that the strain gage output is high enough to drive recording equipment without the use of amplifiers.

Another disadvantage to the use of the large inductance strain gage shown in Fig. 1 on small members arises from the fact that the air-gap change is not measured on the surface of the member but approximately 5/16 above the surface. Because of this fact, errors may be introduced if the strain is due to bending and if the distance from the air gap to the surface of the member is appreciable, as compared to the distance from the surface to the neutral axis. This disadvantage is eliminated in the inductance strain gage shown in Fig. 2.

The strain gage shown in Fig. 1 has three knife-edge feet that rest in tiny indentations in the surface of the member. Two feet are rigidly attached to the frame of the strain gage, and the third is attached to a rocking lever supported by knife edges, as shown in Fig. 3. The rocking lever is terminated with a small armature which is movable between a pair of coils.

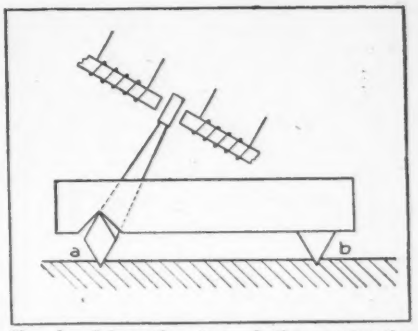


Fig. 3. Schematic view of the construction of the gage of Fig. 1. Movement of the material under the knife edges alters inductance

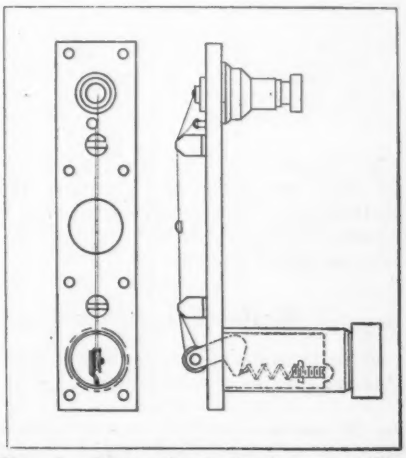


Fig. 4. Constructional drawing of bifilar galvanometer. A mirror bearing loop of metallic ribbon is stretched over a magnet

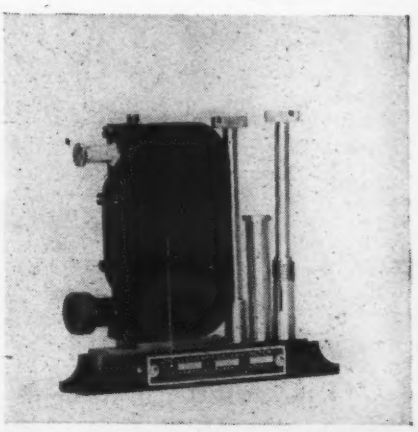
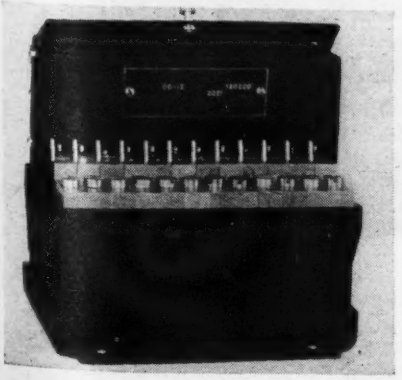


Fig. 5. A bifilar galvanometer. Sensitivity of 50 mm/ma scale deflection at 1 meter can be obtained with low frequency stringing

Fig. 6. Coil type galvanometer. Characteristics are high sensitivity at low frequencies



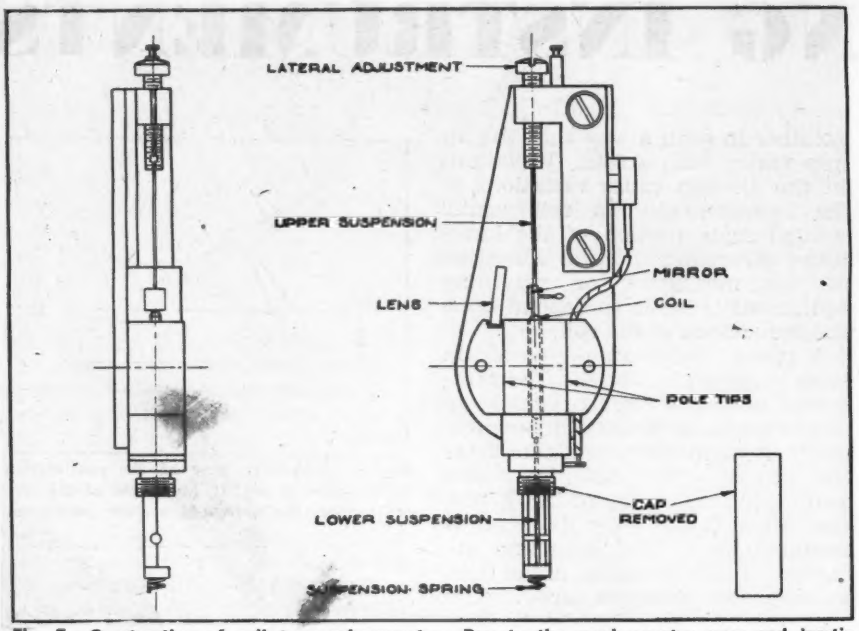


Fig. 7. Construction of coil type galvanometer. Due to the much greater mass and inertia of the moving coil as compared with the bifilar type, frequency response limit is low

The diagram shows that a change in the distance ab between the knife-edge feet will result in a change in the location of the armature between the two coils.

Resistance strain gages

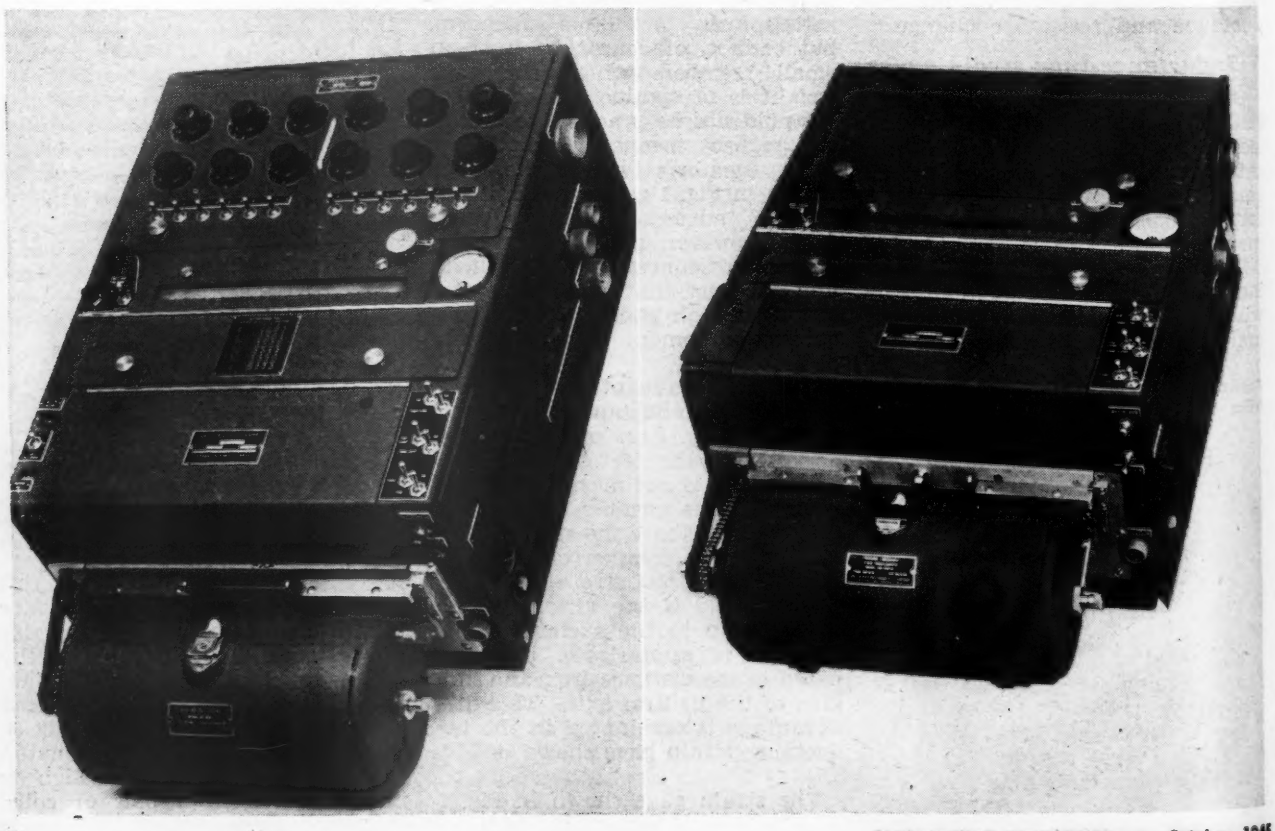
A resistance strain gage utilizes a change of resistance with elongation. This type of gage consists of a resistance element attached so that strain in the member will result in a small dimensional change in the resistance element, producing an actual change in the resistance of the element.

A resistance strain gage is usually a very simple device. The Baldwin - Southwark type SR - 4 strain gage, which is the most successful and generally adaptable resistance strain gage with which the author is familiar, consists of a grid of fine wires about .001 diameter, cemented between two small pieces of thin paper. To measure static or dynamic strain at any point in a member, it is only necessary to attach the strain gage to the member at that point with cement, with the axis of the gage in the direction of the strain component that it is desired to measure.

The resistance change with strain in a wire strain gage, such as the Baldwin-Southwark type SR-4, is partly due to an actual dimensional change of the wire, and partly due to the fact that the specific resistance of the wire changes with strain, a phenomenon discovered by P. W. Bridgeman in his experimental work on the physical properties of materials at high pressures.

Several years before the development of the Baldwin-Southwark type SR-4 strain gage, considerable use was made of another type of resistance gage in which the resistance element consisted of some form of graphite or carbon. A simple construction used by Hull of the General Electric Co. was a strip of paper coated with India ink. Another construction was a thin strip of phenolic material on one

Fig. 8. Semi-portable type of multi-element oscillograph arranged to accommodate 12 to 24 bifilar or 14 to 36 coil type elements. Light for recording is furnished by one or two standard auto headlight lamps. The instrument of Fig. 9, right, is similar, but smaller and lighter



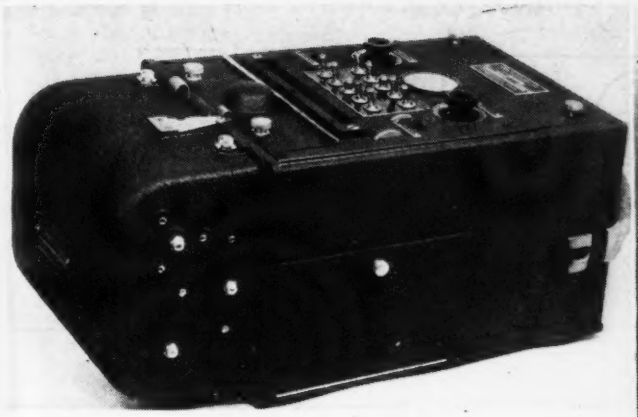


Fig. 10. Portable oscillograph designed for field use such as strain recording in fighter aircraft and other general uses

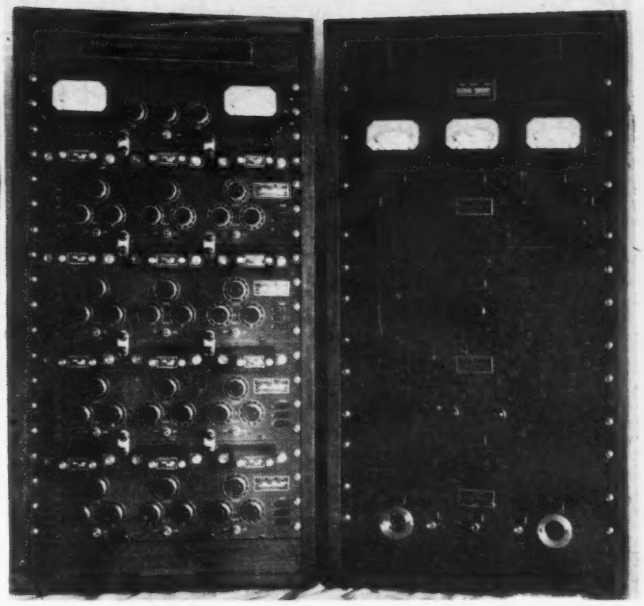


Fig. 12. Strain gage control unit used to apply the gage current to an oscillograph

side of which a thin layer of graphite was deposited electrolytically.

Resistance strain gages employing graphite or carbon have an advantage over those using metallic wire, in that the voltage output is very much greater, but they have a disadvantage in that the resistance is also a function of humidity. Because of the greater stability of the wire-type gage, and because satisfactory amplifier equipment has been developed to handle its low output, this wire-type gage is used almost exclusively at the present time.

Gage factor

The output of a resistance strain gage, in terms of strain, is a function of the "gage factor," which is defined as follows:

$$\text{Gage Factor} = \frac{\dfrac{\text{resistance change}}{\text{total resistance}}}{\dfrac{\text{length change}}{\text{total length}}}$$

A typical wire strain gage has a gage factor of approximately 2, and a resistance of 120 ohms. This means that a strain of .001 inch per inch, or a stress of 30,000 lb. per sq. in. in steel, will result in a resistance change of .24 ohm.

Oscillographs

The oscillograph must be designed for recording quantities that are subject to rapid variation. Oscillographs are usually electrical, in that they are designed to record electric currents, and recording is usually accomplished on a moving chart or sensitized paper or film by small spots of light reflected from galvanometer mirrors.

The galvanometer is the measuring element of an oscillograph. Its moving element, consisting of the mirror and its driving means, must have a high natural frequency, in order to follow rapid variations in the strength of the electric current, and it must be properly damped according to the well-known laws of vibrating systems.

Several types are in common use. The bifilar type, generally used for oscillograph work, consists of a single loop of fine metallic ribbon tightly stretched between the pole-tips of a permanent magnet with a small mirror cemented to the loop at its center. This construction is shown by the diagram in Fig. 4, and a typical bifilar galvanometer is shown in Fig. 5.

The performance characteristics of an oscillograph galvanometer can be expressed by sensitivity, natural frequency, mirror area and degree of damping, and these characteristics can be varied between wide limits in the case of the bifilar galvanometer by varying the cross-section of the suspension strip, the tension in the strip, the length of strip between supports, and the size of the mirror. With the bifilar galvanometer illustrated, sensitivities up to 50 mm/ma at 1 meter can be obtained for low-frequency stringing, and an undamped natural frequency of 10,000 cps can be obtained with a high-frequency stringing with a corresponding sensitivity of 0.1 mm/ma at 1 meter.

The coil-type galvanometer, as as shown in Figs. 6 and 7, is occasionally used where a high frequency response is not required. The moving element in this galvanometer consists of a small coil held in place between the poles of

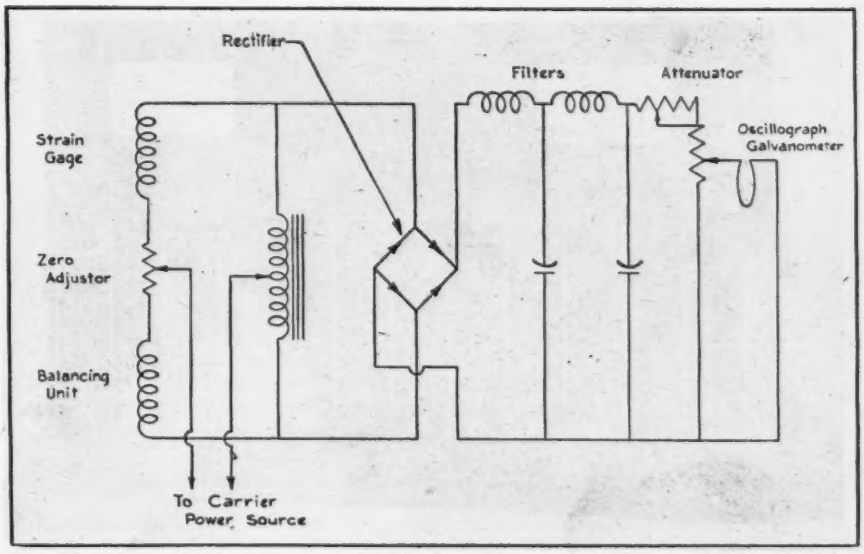


Fig. 11. Circuit of the strain gage unit. This operation from a 2000 cycle carrier source and is accurate for strains up to a frequency of 600 cycles per second

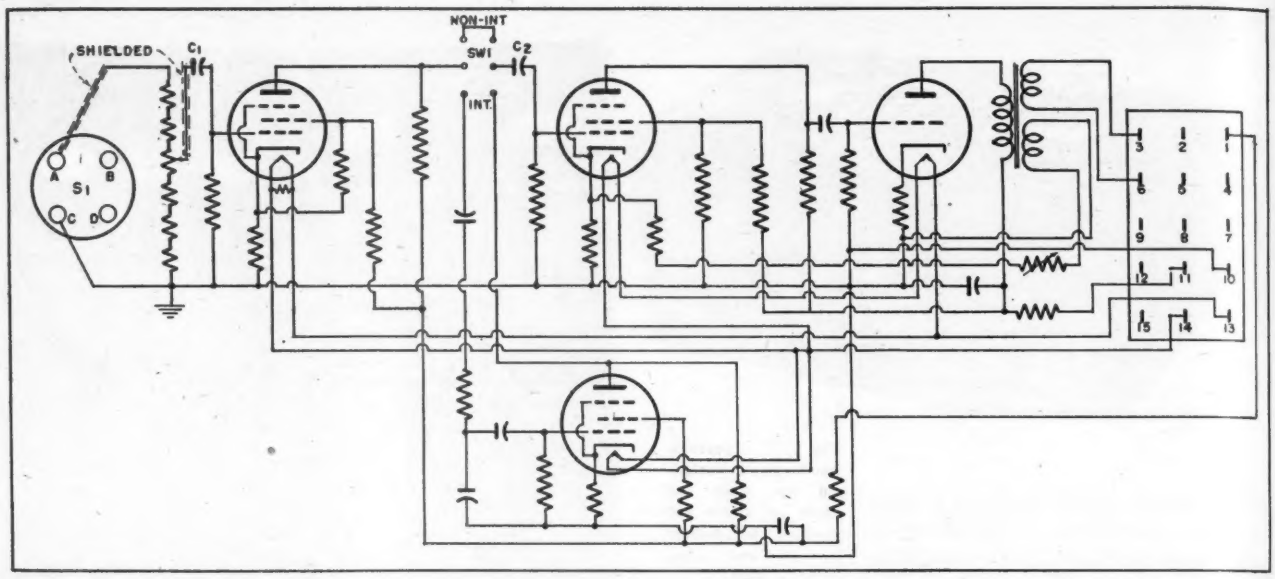


Fig. 13. A typical amplifier circuit for direct current in the strain gage circuit and a wide band low-frequency ac amplifier. This diagram shows the strain gage bridge, the oscillograph galvanometers and the intermediate amplifier equipment. Its response is from 3 to 3000 cps

a permanent magnet by two taut suspensions, in a construction similar to a conventional but miniature D'Arsonval galvanometer. This type of galvanometer is generally useful only in those applications where the maximum frequency response is not greater than several hundred cycles per second.

For low-frequency work where the coil-type galvanometer can be used, it has several distinct advantages over the bifilar type, as a result of its larger mirror. The large mirror of the coil-type galvanometer permits the use of a simpler optical system and a less-sensitive recording paper. The record traces obtained with a coil-type galvanometer are usually somewhat sharper than those obtained with a bifilar galvanometer, because a small amount of diffraction is produced by the small bifilar galvanometer mirror, whereas mirrors used on coil-type galvanometers can be large enough to eliminate diffraction almost entirely.

Multi-element oscillographs

Three multi-element oscillographs widely used for strain recording are shown in Figs. 8, 9 and 10.

This oscillograph, in Fig. 8, is arranged to accommodate 12 to 24 bifilar type OA-2 galvanometers or 12 to 36 coil-type galvanometer elements. Light for recording is supplied from one or two standard automobile headlight lamps. For charts, either sensitized paper or film can be used in widths of 6 or 10 in., and in lengths of 100 or 200 ft. The chart is driven by an internal governor-controlled motor at any one of 16 speeds between 1/3 and 40 in. per sec., and the speed desired is selected by means of a quick-change transmission.

Time-coordinate lines are photographed on the record as it is taken, by means of an internal tuning-fork controlled synchronous motor-driven shutter with a time-line spacing of 1/100-second or 1/10-second as desired. Consecutive record numbers are automatically photographed on the end of each record, and an automatic record length control device can be set to run off any length of record desired after the oscillograph is started. A calibrated viewing screen on the top panel of the oscillograph provides for visual observation of spot positions and deflections even when records are being taken.

The oscillograph shown in Fig. 8 is classed as semi-portable. Its external dimensions are 18 x 10¾ x 28¼ inches, and its weight complete with 12 galvanometers is 125 lb.

The type S8-D oscillograph, shown in Fig. 9, is similar to the above but omits several convenient features, such as automatic numbering and automatic record-length control. It is, basically, a complete oscillograph for general-purpose requirements, however.

The type S12-A oscillograph, Fig. 10, is a portable instrument designed for field use, such as for strain recording in fighter aircraft, as well as for general or laboratory use. It is a 12-element instrument with a number of convenient features such as a time-coordinate device, record-numbering device, automatic record-length control, viewing screen, and magazine load-

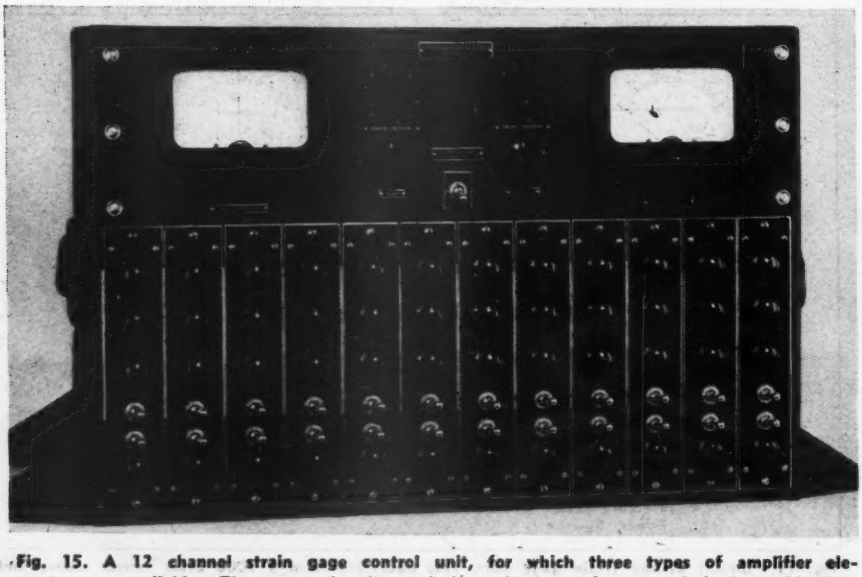


Fig. 15. A 12 channel strain gage control unit, for which three types of amplifier elements are available. These can be inserted in unit to make any desired combination

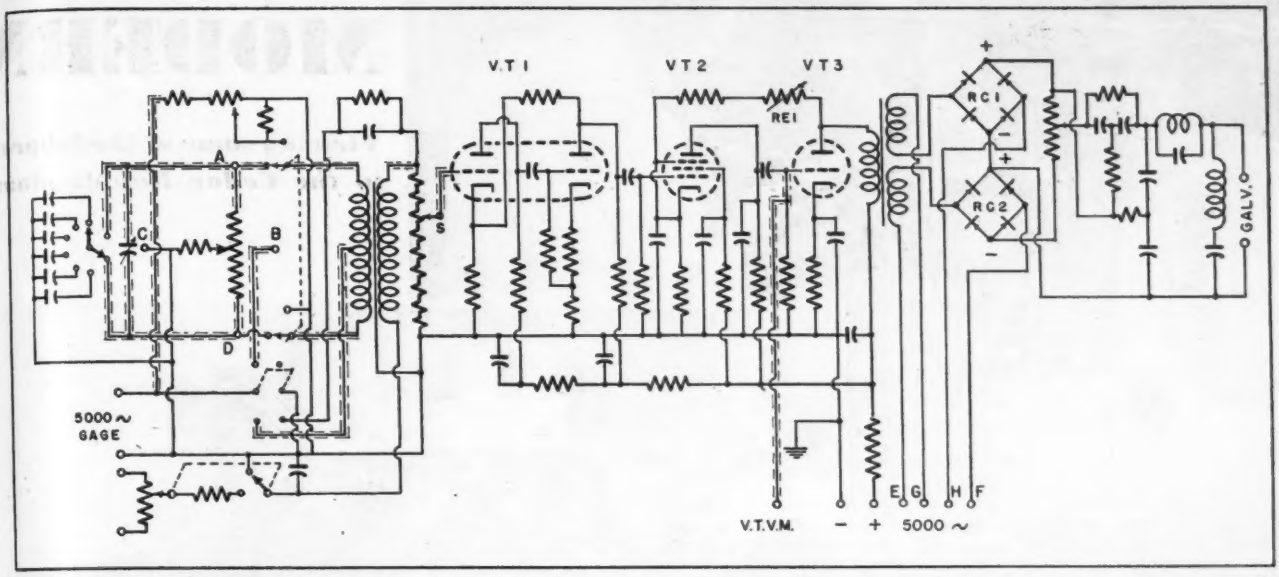


Fig. 14. A typical amplifier using a carrier in the strain gage circuit, and an amplifier with flat frequency response over a range wide enough to cover the carrier and both side bands. This circuit has a phase selective demodulator in the output circuit to remove the carrier

ing, all included in a case 18 x 9 x 8 in., and with a weight of only 40 lb.

It can be equipped with 12 bifilar type OA-2 galvanometers or with one 12-element type OD-12 coil-type unit. Six-inch recording chart is loaded into the record magazine in 100 ft. lengths, and any record speed desired between ½ and 48 inches per second can be selected by inserting the proper change gears into the gear train, accessible through the hinged cover on the side. All controls, adjustments, and indications are mounted on a single control panel on the top.

The term "strain-gage control unit" has been assigned to all the auxiliary electrical equipment between the strain gages and the oscillograph. This unit is usually of multi-element design and may or may not contain amplifiers. Several variations of strain-gage control units will be described and illustrated.

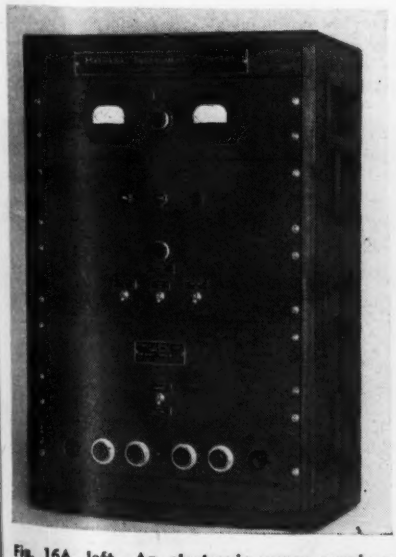
Amplifier equipment

Large inductance-type strain gages, such as the type shown in Fig. 1, may drive their oscillograph galvanometers directly without the use of amplifiers. A typical circuit for this type of operation is shown in Fig. 11, and a complete 12-channel strain-gage control unit which houses the balancing gages, adjustments, rectifiers, filters, etc. for 12 separate channels is shown in Fig. 12.

The equipment illustrated in Figs. 11 and 12 operates from a 2000-cycle carrier and provides a strain record that is accurate for static strain and for dynamic strain, up to a frequency of 600 cycles per second. No amplifiers are required. The strain gage is connected in a bridge circuit consisting of the strain gage, a balancing unit similar to the strain gage, and a center-tapped inductance unit. Carrier power is supplied to two corners of the bridge and the carrier voltage across the other two corners is a function of strain. The voltage output from the bridge is demodulated to remove the carrier by means of a full-wave rectifier and proper filters, and then applied to the oscillograph galvanometer terminals through an attenuator, as shown in Figure 11.

In general, resistance strain gages and small inductance gages require the use of an amplifier be-

(*Continued on page* 182)



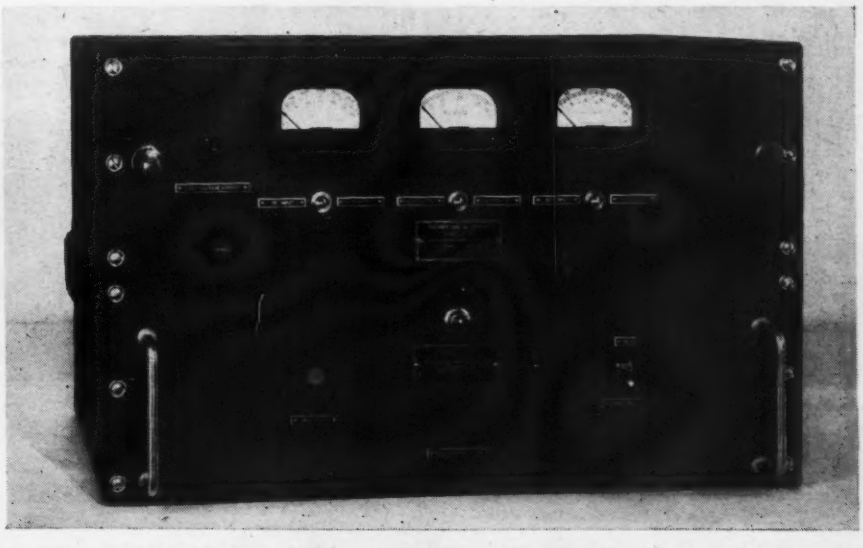


Fig. 16A, left. An electronic power supply unit to supply power for 24 large 2000 cycle inductance strain gages. Fig. 16, right. A power supply unit designed for use with type MRC-10 control unit to supply 5000 cycle power for carrier circuits and also all dc for amplifier elements

MODERN

Viewing some of the labora-
in the Cedar Rapids plant

▲ Position of circuit elements, shields and leads is critical factor in design of higher frequency equipment. At this stage, months are spent in these specialized laboratories arranging and proving circuit for its intended purpose

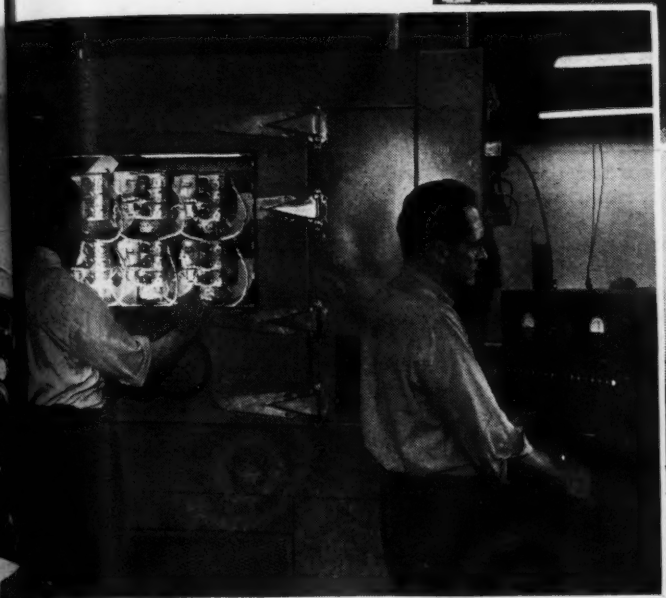
▼ Although components, sub-assemblies, wiring and soldered joints have been inspected and tested, each finished transmitter is completely operated into a simulated antenna load. Here measurements of all characteristics are recorded

▲ The communication equipment produced often departs from current conventional design. Therefore much of the needed test and control equipment not being commercially available, is designed and built in the Test Equipment Department of the Collins Radio Company

▼ Collins Autotune heads are synchronized in a sound-proof booth so that the pawls are heard when they drop. Indicator lights show which channel is electrically selected. Large dial gives precise electro-mechanical synchronization simplifying test of complete assembly

Radio PRODUCTION

tory and factory methods of the Collins Radio Co.



▲ (Top right) Main plant of the Collins Radio Co., containing 150,000 square feet, houses administration, engineering and manufacturing. (Above) Test of Autotune assemblies with torque meter at "forty below." (Right) Tubes are checked under actual operating conditions. Rotary tube checker in foreground preheats filament before a tube reaches the high-voltage rectifier tester or the high power tube tester at rear

▼ (Below) Each laboratory includes well equipped machine shop and assistants. (Below right) Each aircraft transmitter is tested in climate chamber, which simulates the complete gamut of service temperatures

IMPROVING RECORDINGS

By **NORMAN C. PICKERING**
Control Instrument Company, Inc., Brooklyn, N. Y.

How to get the most out of phonograph records including a new design for a volume expander to increase 'presence'

• It has long been realized that reproducing phonograph records in the home in such a manner as to invoke all the psychological responses experienced in the concert hall is a formidable problem. At the outset we are faced with the realization that the atmosphere of excitement and expectancy which gives glamour to all performances in a concert hall will be entirely missing in the familiar and prosaic living-room. And, unless the room is very large, the feeling of acoustic spaciousness which contributes so much to the grandeur of the sound in a good auditorium just isn't there, unless some clever auditory faking is done.

It is the purpose of this article to explain some of the more easily applicable methods by which reproduction of phonograph records can be enhanced to the point where, instead of being merely a reminder of an actual performance, the playing of a recording can be a thrilling musical experience in itself.

All musical performances can be analyzed into the simple elements of rhythm, dynamics, pitch and tone-color. If these elements are present in the proper quantities at the proper times the result is a satisfying musical performance. Rhythm, of course, being a time-sequence function, is dependent on turntable speed and stability. It is important that the absolute time-sequence of successive tones in a musical performance be maintained accurately, because "tempo" is the most important single factor affecting the emotional response to a musical performance. Inasmuch as "pitch," or fundamental frequency, is also affected by turntable speed, it is most important to rotate the record under the pickup at a steady speed of exactly 78.26 revolutions per minute. The word "steady" in this statement has great significance inasmuch as the "wow" caused by non-uniform turntable rotation is the most irritating distortion possible. Unfortunately, many commercial pressings are released with the "center" hole any place but in the center. With a disc like this, the "wow" will be bad even on a perfect turntable, and since the eccentricity is contant it will be more noticeable toward the center of the record. This is shown in the following derivation:

Let R = radius of a given groove, inches

ω = Angular speed of turntable, radians per second

λ = Wavelength of modulation, inches

f = Frequency of output voltage from pickup

For a record with no eccentricity:

$$f = \frac{\omega R}{\lambda}$$

The wavelength of a constant frequency tone is directly proportional to the distance from the center of the record.

Frequency varies

Let us assume a constant frequency record, where the center of rotation is not at the true center of the grooves. (The groove on a record is a continuous spiral, of course, but for this discussion no error is involved in assuming a given groove to be a circle.)

Let d = distance in inches from true center to center of rotation. Then the frequency will vary from

$$f_1 = \frac{\omega(R+d)}{\lambda} \text{ to } f_2 = \frac{\omega(R-d)}{\lambda}$$

$$f_1 - f_2 = \frac{2\omega d}{\lambda}$$

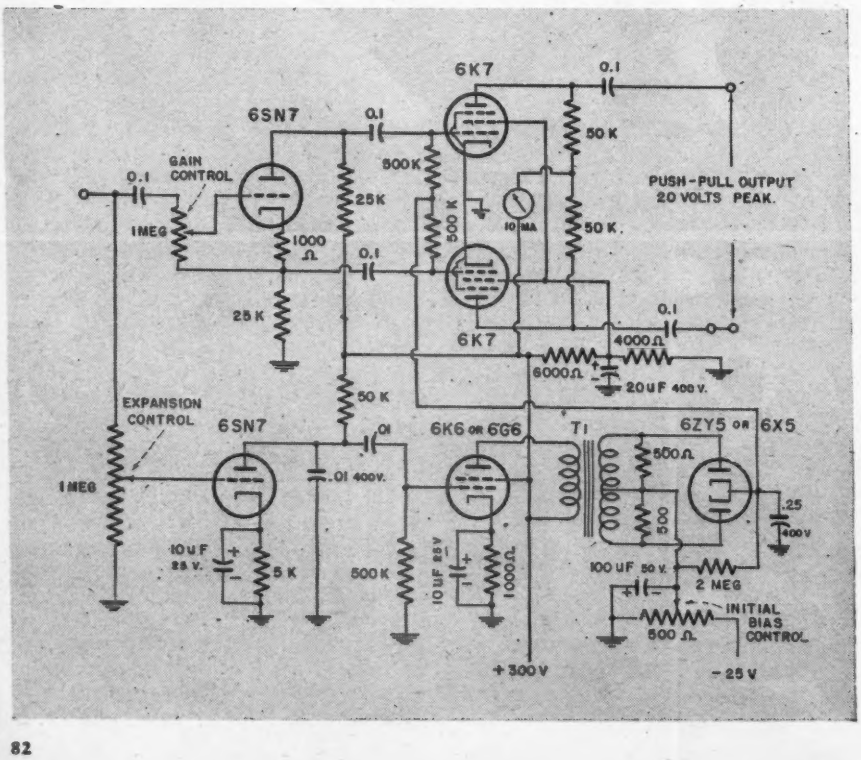


Fig. 1. Schematic diagram of the volume expander. The signal is amplified through one single and one push-pull stage. In the bottom circuit the same signal is amplified and rectified to bias the push-pull grids

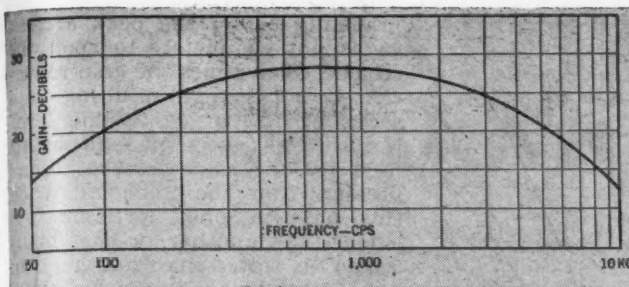


Fig. 2. Gain in db versus frequency curve for the amplifier of Fig. 1

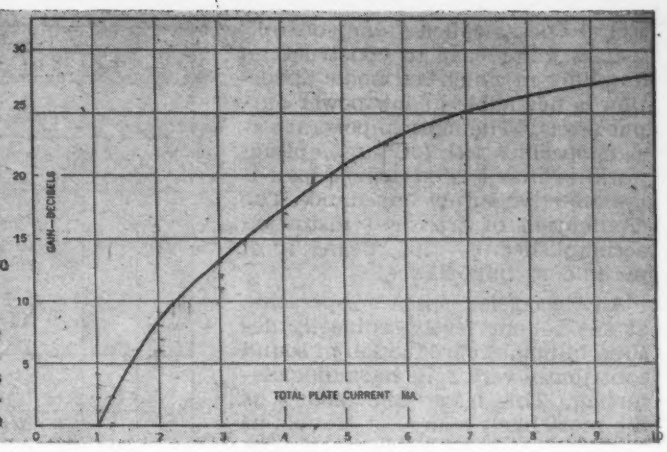


Fig. 3. Calibration of the 10 ma meter shown in the plate feed circuit in Fig. 1. The range of volume expansion available depends on the initial plate current. The 500 ohm potentiometer shown in Fig. 1 adjusts the fixed bias on the grids of the control stage of the amplifier. The relaxation time of the expander is made much slower than the response

The relative frequency change is

$$\Delta f = \frac{f_1 - f_2}{f} = \frac{2\omega d/\lambda}{\omega R/\lambda} = \frac{2d}{R} \quad (1)$$

From the Bell System Technical Monograph No. B-621 it is found that the minimum perceptible increment of pitch for frequencies from 500 cycles to 2,000, which is the band in which most of the energy of music appears, is less than 0.005 at normal levels. Since these measurements were made under laboratory conditions with pure tones, we will double the amount for complex waves in music under usual listening conditions. This gives us a limit of 0.01 for Δf.

Substituting in equation (1)

$$0.01 = \frac{2d}{R} \quad (2)$$

A common minimum value for R is 1.7 in. (There are records with even lower minimum groove radius.)

Substituting in equation (2) and solving for d

$d = .0085$

This represents the eccentricity at which pitch variations become noticeable, hence objectionable. In this light it is astonishing to realize that many commercial pressings have been purchased where the eccentricity is 0.020 inches or more!

A partial remedy for these records is to have a centerpin on the turntable which is about 0.040 inches smaller in diameter than the standard 0.281 inches. A tubular sleeve with the standard outside diameter would be normally placed on the centerpin. When an eccentric record is encountered the sleeve would be removed and the record moved about on the turntable until the grooves run true. A mark on the record label would simplify future location of the true center. With a light-weight pickup the weight of the record will be enough to hold it in position on the turntable. With some pickups extra weight at the center of the record will be necessary.

If the music on the record is of such a nature that there are no notes sustained for more than one rotation of the turntable, quite a large amount of eccentricity can be tolerated. However, if the recording contains music having sustained tones played by instruments not normally employing vibrato, such as the clarinet, horn or piano, the limit of eccentricity given here may be even too much.

Tone-color

Tone-color is the name given to the character of the sound. It is well known that the quality which enables us to distinguish between two instruments playing the same fundamental sustained tone is the number and relative intensities of the "overtones" or harmonics which are multiples of the fundamental frequency.

High frequency response is the controlling factor in the reproduction of the distinguishing harmonics of musical instruments. This has been the most discussed characteristic of reproducing systems ever since electronic amplification became popular. It should be clearly pointed out that a high upper limit of frequency response is not in itself a desirable characteristic. In fact, for phonograph record reproduction it is a decided disadvantage, as will be discussed below. What is important is that throughout the transmission band of the system there be no serious discrimination between adjacent frequencies. This dictates smooth frequency response.

The effect of jagged high frequency response is to accentuate some harmonics of certain tones, and attenuate others. The order of the harmonics which are altered changes for different tones in a given system. This produces the curious and displeasing effect of changing the tone color of an instrument in a manner which varies with the tone being played. As an example, a clarinet playing a chromatic scale with uniform tone quality would be reproduced so that adjacent tones differed seriously in timbre and even in loudness. In extreme cases adjacent semitones could assume the character of clarinet, flute and oboe respectively.

Smooth frequency response also results in much less unpleasant "surface noise." The ear apparently responds to the peak noise, rather than the average noise, in this case. This phenomenon gives the effect of an increased signal-to-noise ratio on a given record when played on a system having smooth frequency response over that when played on a system having jagged response over the same transmission band.

Smooth response is difficult to obtain with an ordinary single cone loudspeaker. Paper cone "tweeters" are particularly non-uniform in frequency response, even though they do contribute a lot of high frequency energy. However, there are available loudspeakers of conventional design which have fairly smooth response. A good horn-type loudspeaker of the metal diaphragm type is the best obtainable for smooth response and low distortion.

Harmonic distortion

Another important factor in natural rendition of tone-color is the elimination of harmonic distortion. The addition of harmonics to the fundamental tone, other than those present in the original sound, is not easily tolerated by the musical ear. The "raw" sound of a distorted wave is most unpleasant, and is the primary cause of the habitual over-

use of the so-called "tone control."

It is quite easy to construct an amplifier in which harmonic distortion is negligible at low power output levels. The most important design specification for an amplifier working into a loudspeaker load is low effective output impedance. The elimination of transient distortion accomplished by this means is of paramount importance.

Any good loudspeaker operating at the volume levels ordinarily desired in home reproduction of sound contributes very little harmonic distortion. This leaves the pickup as the most likely source of trouble of this kind. A good magnetic pickup gives the "cleanest" reproduction of any kind available today. Unfortunately good magnetic pickups are not inexpensive and inexpensive magnetic pickups are, as yet, not good. There should be developments in this field in the near future, however.

It should be pointed out here that some record distortion cannot be eliminated by any means. Records which have high level passages close to the center can never be reproduced with entire lack of distortion. Good equipment will, however, reduce it to the point where it is hardly objectionable.

A decided improvement in the sound of phonograph records can be obtained by sharply limiting the high frequency response of the system to 7500 cycles. This represents about the highest useful frequency which appears on most pressings commercially produced. Nothing appears in the region above 7500 cycles, therefore, but products of harmonic distortion, and surface noise. The improvement in quality realized on most records by eliminating these very high frequencies is considerable.

Filter

The low pass effect can be obtained by restricting the upper frequency limit of either the pickup, the amplifier or the loudspeaker. Since it would be desirable to have a wider frequency band available for very noise-free records cleanly recorded, a filter in the amplifier which can be switched in and out is convenient.

The dynamic range, or volume range, is the final characteristic of a reproducing system to be discussed. Although an orchestra in a concert hall may have a volume range of 50 db or so, it is impossible to maintain the correct relative volume levels on phonograph recordings. The amplitude of the modulation in the phonograph groove is severely limited by the groove spacing, by the overload

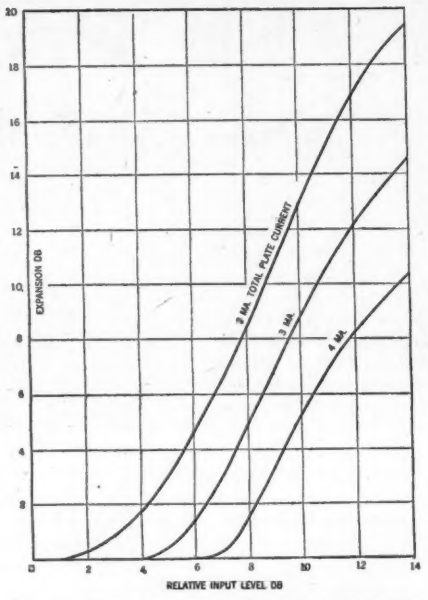


Fig. 4. Expansion in db plotted against relative input level. Higher plate currents reduce the expansion which is obtainable

limit of the recording head, and by the ability of the reproducing stylus to follow the groove.

Results of measurements on many commercial phonograph records show a maximum modulation level of 30 db above surface noise, with an average value of 25 db. Many records show a maximum level of only 20 db above surface noise. All measurements were made on records having the same absolute level of surface noise, and were of similar types of music, so that the high level passages would represent about the same sound pressures in the concert hall.

A 30 db volume range might be considered by some listeners to be too great. If the music is being used as background for conversation this is usually the case. Many others, however, consider a range of as much as 40 db to be desirable in the home. If the room noise is low, so that the quiet passages can be reproduced really pianissimo, a fortissimo of 40 db above this level is very impressive. If all the foregoing factors such as frequency response, distortion, etc. are well taken care of the performance begins to become excitingly real.

Some form of volume expansion is indicated to produce the dynamic range mentioned above. If the volume compression used in recording were automatic and of known constant characteristics it would be a simple matter to build a volume expander with inverse characteristics. Unfortunately, the compression actually used follows no pattern, being entirely manual. Usually the man who is "riding gain" attempts to anticipate peaks and reduce gain gradually before the peak arrives, so as not completely to spoil the climax. Sometimes the gain reduction is not steady, resulting in a series of "steps" of volume level. Not always is the same gain setting used for the same level of sound pressure from the orchestra. When this happens one "fortissimo" is louder than another, or one "pianissimo" is softer than another. In some cases "piano" may be louder than "forte" or "pianissimo" louder than "piano." When this happens no volume expander can remedy the situation.

Circuits

There have been many different volume expanding circuits described in the literature at various times. Some of the simpler ones involve such schemes as short-circuiting the output stage with a lamp bulb which increases its resistance at high volume levels. The long time lag is the most obvious disadvantage of this system. Furthermore, if the output amplifier is a good one, having low output impedance, a large change of load resistance will have little effect on anything but harmonic distortion!

The usual expander has a single control tube, such as a 6L7 or 6K7, rectifies the audio signal, filters it, and applies it as a variable bias to the control grid. The gain changes with bias, hence with audio level. A system of this type can never be made with a time lag of less than 0.1 second, and can never be entirely free from harmonic distortion. If these two objections are overcome this system of volume expansion can be very effective. The expander to be described does eliminate these objections, while retaining the desirable features of the electronic volume control.

Because of the manner in which the volume compression is accomplished the characteristics of the volume expender should be as follows:

(1)—Expansion should not start until the volume level reaches a certain minimum value.

(2)—Expansion should be fairly linear with input level once it does take effect.

(3)—The distortion introduced by the expander should be virtually zero.

(4)—The amount of expansion should be limited to a specified maximum.

The latter provision is important. These "steps" in volume, referred to above, which almost always occur at rather high levels, are magnified by the expansion. Consequently, too much expansion will

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INCENTIVE PAY FOR ELECTRONIC ENGINEERS

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Compensation Plans Based upon Individual Achievements and Inventions as Well as Company Prosperity. Rewards for Technical Men Comparable to Earnings of Sales and Other Executives

• How can an individual's contribution to the general good be measured? It is true that outstanding artistic or scientific achievement usually does get "delayed" recognition—but often so much delayed that its recipient is not around to receive it.

On the other hand, commercial, military and political success usually has had wide acclaim, with timely and substantial benefits to the man of merit.

Since the popularization of the corporate form of business and the far-reaching tendency to specialization in our manufacturing plants and research laboratories, the engineer in his own right has become more and more a mere cog in the wheel: A cog to be oiled when it squeaks, but merely praised when its expected silent, but efficient, operation goes on, year in and year out!

Labor, because of past evils, was forced to seek methods of enforcing its rights. Sheer weight of numbers and organization has produced such a far-reaching political result that today an untrained eighteen-year-old girl starts her factory job at a 20 per cent higher rate than was paid to college-graduate engineers starting in with electrical manufacturing companies at the peak of the 1929 boom. In those same years great communications research laboratories paid college trained engineers $27 and $30 per week to start, with an increase of 10 per cent to $33 within six months if performance warranted.

The trained engineer of above-average ability started right in to specialize, and, unless he departed from his chosen profession, found himself ten years later to be one of a handful of scientists who, of all the people in the world, knew most about that special subject. The trouble is that he was supposed to be so completely overjoyed by the possession of this special knowledge—and his patents which are not his—that he would be completely unaffected by his wife's oft-repeated comments that they can't afford to live with or up to his contemporaries who became lawyers, doctors, investment bankers, industrial executives, or went into business for themselves.

Is there a yardstick by means of which the value of an electronic engineer to his organization can be gaged? The matter of the compensation of engineer-executives is a complicated one and a subject of grave importance not alone to the engineers involved but to the industry itself. Generally, engineers are underpaid by other-industry standards. Some sensible, equitable plan must soon be evolved.—Editors.

Rented for life

True, the corporation provided comfortably heated, lighted and well-equipped office and laboratory facilities. True, it provided a budget and a promise of life-long security; these latter had a, by then, almost-forgotten, embarrassing unreality about twelve years ago. The engineer who behaved himself and became top-notch man in his field, today in most cases, has as much future and "cross commercial" recognition as the heating plant in the laboratory where he dwells. He is a machine, rented for life and expected to function—regularly and well.

Some forward-looking companies have seen this engineering cul-de-sac clearly, and whether by sound policy or by expedient, under today's competition for technical men, have set about to provide substantial recognition for engineering achievement. These companies, however, are few and far between so that our engineer today is by and large little better off than was the skilled Greek scholar during the early Christian era in relation to his Roman master-owner.

Unless better methods are devised quickly and are made effective, the coming years will see the best engineering minds seeking more lucrative fields and the less able men banding together in union organization to force the issue. Timely action by employers can avoid this, but what action?

Some employers have tried a lazy yardstick like $100 per patent application. Others have made promises that rivaled the traditional "blue sky" promoter. In a few instances engineers by retaining competent and understanding counsel have been protected by controlling their contributions. By and large the fear of "going overboard" in wholehearted recognition has retarded any satisfactory solution to this problem.

We believe that a general pattern with special deviations to suit each individual case is a "must" for forward-minded companies, during this period of applying war-born developments to peacetime uses.

In the first place, good engineering means so much to industrial progress that any reasonably conceived incentive plan must perforce pay dividends. If it only eradicates

this practice of a company's engineers' saving their best ideas for a "special deal" with someone else or really doing their best work "on the side" for pay, it will make plenty of sense. After all, venture capital expects large rewards if results are produced. Labor in general works for an incentive based on increased production. Salesmen operate on commission. Many executives have bonus or stock option arrangements. Why should engineers be unique?

Engineering in order to call and hold good minds and to inspire the profession to its maximum effectiveness, should be provided with attractive and adequate incentives. In such a fast moving branch of engineering as our electronic industry only the best mentalities can keep up. Those who have the ability should be compensated in keeping with their achievements. To do so poses a personnel and administrative problem.

We present here certain suggestions in the hope of stimulating thought and provoking comment. The following are in a sense alternates, but can be combined in whatever way seems best for any particular group or company:

Compensation plans

1. Straight periodic salary on a term contract basis with provision for reexamination and adjustment of the rate within classification limits at stated intervals by the department head.
2. A straight periodic salary with a quarterly, semi-annual or annual lump sum bonus determined by the department head with the bonus amount set after examination and evaluation of one or more of the following:
   - A. Company profits
   - B. Inventions conceived
   - C. Patents applied for (value and number)
   - D. Patents issued (value and number)
   - E. Original ideas of value to production for all the range of cost saving, work simplification, etc. items
   - F. Independent thinking
   - G. General cooperation
   - H. Saneness of behavior
3. A base periodic salary plus a regular additional percentage determined on a calculable basis such as this: Of the entire company or division earnings, actual or estimated, before taxes, a predetermined fraction is set aside as an "Engineering Incentive Fund." This fund then is administered by the department head on a periodically revised basis and distributed as additional compensation to all engineering group people with each individual's share set much as in the manner outlined in paragraph 2 above.
4. A straight salary plus a periodic royalty calculated somewhat as follows:

Evaluating results

Each substantial contribution and/or patent introduced is to be assigned an arbitrary original value. This value will be revised each year. Each engineer's individual part in that invention will be determined on a percentage basis (all-50 per cent-25 per cent, etc.). A "ledger account" to be opened where all such values are entered to the credit of each individual engineer. This capitalized basis would handle much in the manner done by patent holding companies with cross-licensing agreements. Periodic distribution of "royalties" would be made to each "owner." These would continue only during his term of employment. A fair percentage, say 5 per cent, of the assigned value would be allowed for each element. The total calculated sum of all royalties would be paid by the company to this fund periodically. Depreciation of the patents over their life would be unnecessary as the royalty payments would cease on expiration or prior obsolescence. To avoid confusion this type of account would be completely independent from company books and have no relation thereto. In other words, the engineering group would have their own patent pool—company supported—

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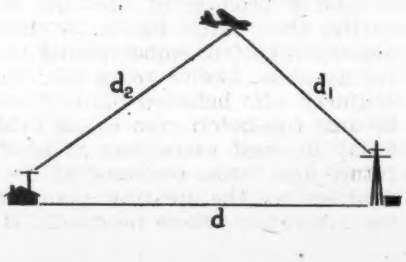
TELEVISION REFLECTIONS FROM AIRPLANES

A question frequently asked is: Why can an airplane flying overhead at a speed low compared with a television signal (say 250 mph against some 650 million mph) produce such a violent signal fluctuation in a television receiver. This phenomenon is a direct visual illustration of the same basic principle used by radar: the remarkable degree to which ultra-high-frequency waves are reflected. Referring to the diagram, the condition is as follows:

A plane is flying at a height h, which is usually a small part of the direct separation distance d, between the transmitter and receiver. Here two signals can reach the receiver—the second signal being reflected by the plane. If these signals arrive in phase the total received signal is augmented. However, since the plane is moving, the second path is continually changing in length—one instant the reflected signal adds to the normal value and the next instant it subtracts. At say 240 miles per hour a plane may move through about 21 wavelengths of the signal per second if plane and signal directions are parallel. This fluctuation would certainly be too fast to be noted by eye, if the radio equivalent of the Doppler effect were effective.

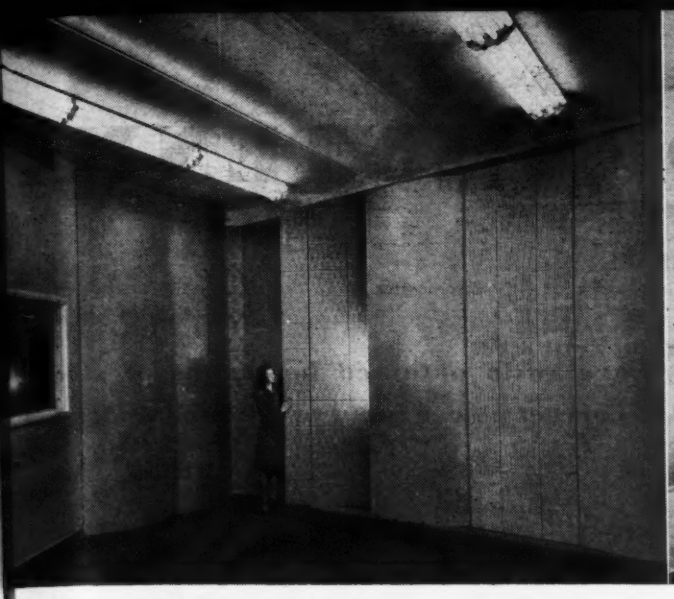
How airplanes may cause video signals to fluctuate

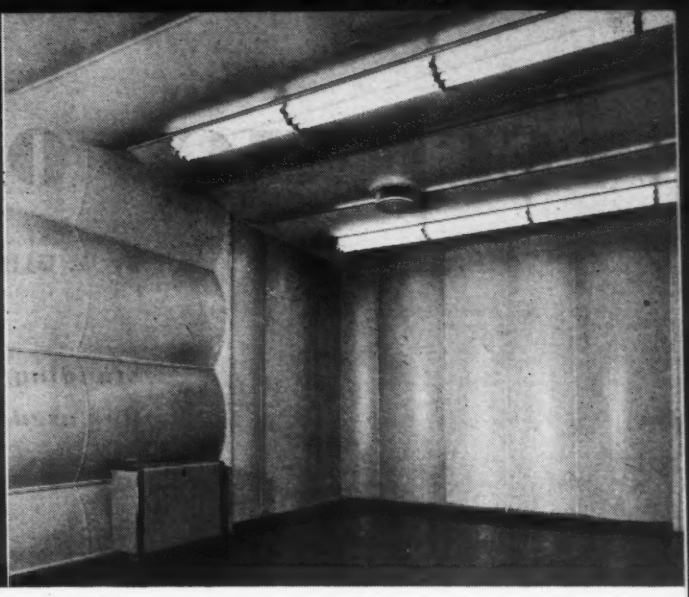


However, the actual path length over the reflected path is equal to the sum of that from the transmitter to the plane (d_1) plus that from the plane to the receiver (d_2). If the plane is over a point between these locations, d_2 is increased at approximately the same rate that d_1 decreases (or vice-versa if the plane is moving toward the receiver). If the sum of d_1 and d_2 remained exactly a constant, a ghost image and not a fluctuating picture would result.

When the plane is over territory between the stations, but not necessarily moving in the same line as the television signals, the common effect is that the total combined path d_1 and d_2 creeps up one or loses out one wavelength at definite intervals along its path. A varying signal strength is received therefore which causes more or less violent fluctuation of picture intensity.

The signal fluctuation rate may change over wide limits depending on the speed, height and direction of the plane. If it is flying outside of the territory between the transmitter and receiver and in a path roughly the same as that taken by the television signal, it produces a signal change twice as rapid as the Doppler rate (twice the 21 wavelengths figured in the example above). However, if it happens to be flying at a larger angle with the signal direction, such as at right angles to it, it can still produce a fluctuating effect.





Broadcasting studio with polycylindrical surfaces having random resonance characteristics at low frequencies. Reversible sections on one end wall provide a two-to-one range in reverberation time. Highest time is 1.4 seconds. The cylinders are vertical as well as horizontal

SOUND STUDIO DESIGN

• To obtain uniform acoustic reinforcement with all frequencies of speech and music without having any unwanted resonance points, engineers of KSL broadcasting studios, Salt Lake City, have redesigned the walls of the studio. The effect from the broadcaster's point of view is that he can hear himself and others more clearly, and he applies less effort to achieve a given acoustic level. In addition, placement of microphones and instruments seems far less critical and the number of microphones is reduced to the point where in most cases one alone gets good results with orchestra.

The object of adding the polycylindrical surfaces, shown in the photographs is to increase the diffusion of the sounds, particularly those of lower frequencies. Random resonance of the cylinders through the low frequency range offers considerable absorption by diaphramic action. It also increases diffusion. This means that the reverberation time can be fairly long without spoilage of articulation.

Fixed absorbant is located in corner. The cylinder surfaces are 1/8 in. tempered masonite of standard 4-ft. stock. The radius of curvature is 4 ft. Designed for drama, this studio was built for bright sound effect. Absorption was then added until drama requirements were satisfied

TECHNIC OF ANTENNA

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Standing wave ratio obtained by means of slotted line used to correct power input to antenna under test

• The main purpose of the VHF directional antenna is to increase the field strength at the receiving point, without the necessity of increasing the power of the transmitter. Since the half-wave dipole is the simplest type of VHF antenna, it is customarily chosen as a "reference" antenna and the effectiveness of any other antenna is evaluated in terms of the increase of the field strength at the receiving point in comparison with the field strength which would be produced by the reference dipole, when fed with the same power. In other words, if "reference" antenna, when fed with power P, produces the field strength E_R at the receiving point and if directional antenna, when located at the same point as reference antenna, and fed with the same power, produces the field strength E_D at the same receiving point, then the antenna field gain (in db) is defined as:

$$(AFG)_1 = 20 \log \frac{E_D}{E_R} \qquad (1)$$

An antenna gain of 10 db means therefore that the directional antenna produces a field strength about three times as high as the reference one. To produce the same field strength with the reference antenna would require ten times as much power.

Given $\frac{E_D}{E_R}$, $(AFG)_1$ can be found from Fig. 1.

From the above definition it follows that the gain measurement reduces to the field strength measurement: a) when reference antenna is used; b) when directional antenna is used, under the proviso that both antennas are fed with the same power. Hence, for antenna gain measurements, and in addition to the directional antenna under consideration, the following items are required:

1) Reference Antenna
2) Receiving Field Strength Measuring Equipment
3) Transmitting Power Measuring Equipment

If the directional antenna under consideration is of such a type that it has some form of half-wave dipole as a driving (active) element, this element, after the removal of all other elements, can be used as a reference antenna. Otherwise a specially built half-wave dipole, located at the point where the directional antenna is placed afterwards, can be used as a reference antenna.

Relative measurements

Since in the antenna field gain formula (1) only the ratio of the field strength is involved, only relative values of the field strengths need to be measured. If the proper field strength measuring equipment is not available, any calibrated receiver (without avc) can be used for the same purpose.

Any appropriate equipment can be used for the measurement of power input, but a measuring section of the feeder line is convenient and can be used with particular advantage in the way described below.

If, as is customary, a coaxial

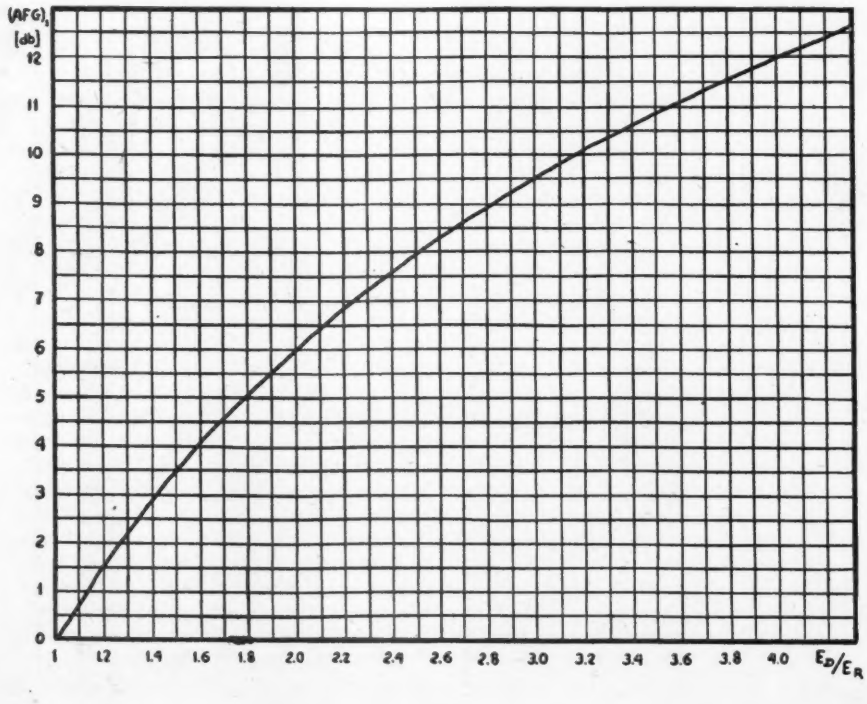
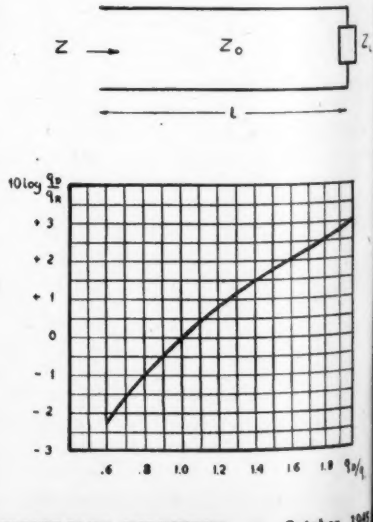


Fig. 1—Curve showing the antenna field gain in db when the ratio of field strength of directional and reference antenna is known. Fig. 3—Input impedance Z of line is resistive at point of voltage minimum. Fig. 4—Correction for different power input



GAIN MEASUREMENTS

feeder is used, the measuring section of the feeder line takes the form of, approximately, a wavelength section with equidistant holes in the outer conductor to permit the measurement of the voltage distribution. These holes are conveniently numbered 0, 1, 2 .... n starting from the near end. An example of such a measuring section is shown in Fig. 2.

As far as the choice of the location of the measuring section is concerned, it is desirable to place it as near to the antenna as possible. Since this usually requires a serious alteration of the existing installation, however, the simplest solution is to place the measuring section between the transmitter and the antenna feeder proper.

Power measurement

If the input admittance of the feeder (with the directional antenna connected at its far end) is G+jB and if the input voltage is V (rms) then the average (active) power delivered to the feeder is

$$P = GV^2 \qquad (2)$$

If the feeder is lossless, this power is also equal to the power delivered to the antenna.

If the feeder introduces some losses, there will be a continuous loss of power along the feeder and the power delivered to the antenna will be smaller by the amount lost in the feeder itself.

Hence the power measurement by means of the measuring section is based on the simultaneous measurement of the conductance and voltage at any point of the feeder. Moreover, if between the antenna and the feeder input there is an appreciable length of the feeder, the power loss due to the attenuation should be taken into consideration in the way explained below.

To measure the power the following procedure seems to be the simplest:

The voltage maximum, V max, and minimum, V min, are measured on the measuring section. The ratio $\frac{V\,max}{V\,min}$ gives the standing wave ratio q:

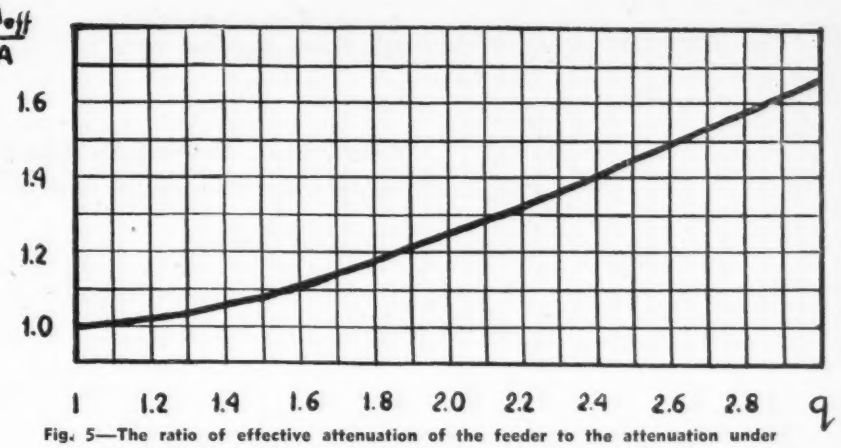


Fig. 5—The ratio of effective attenuation of the feeder to the attenuation under matched conditions is plotted against the measured voltage standing wave ratio

$$q = \frac{V\,max}{V\,min} \qquad (3)$$

As is known from transmission line theory, the input impedance of the feeder at the point of minimum voltage is purely resistive and has the value:

$$Z = \frac{Z_0}{q} \qquad (4)$$

where Z_0—characteristic impedance of the line.

Therefore, the input admittance at the same point is

$$Y = \frac{1}{Z} = \frac{q}{Z_0} \qquad (5)$$

and the power

$$P = YV^2min = \frac{qV^2min}{Z_0} \qquad (6)$$

If, with the directional antenna connected, the measured power is P_D whereas with the reference dipole connected the measured power is P_R, then the antenna field gain $(AFG)_2$ corrected for the constant power input to the feeder is:

$$(AFG)_2 = 20 \log [(E_D/\sqrt{P_D})/(E_R/\sqrt{P_R})]$$
$$= 20 \log \frac{E_D}{E_R} + 10 \log \frac{P_D}{P_R}$$
$$= (AFG)_1 + 10 \log \frac{P_D}{P_R} \qquad (7)$$

where $(AFG)_1$ is given by the formula (1).

(*Continued on page 222*)

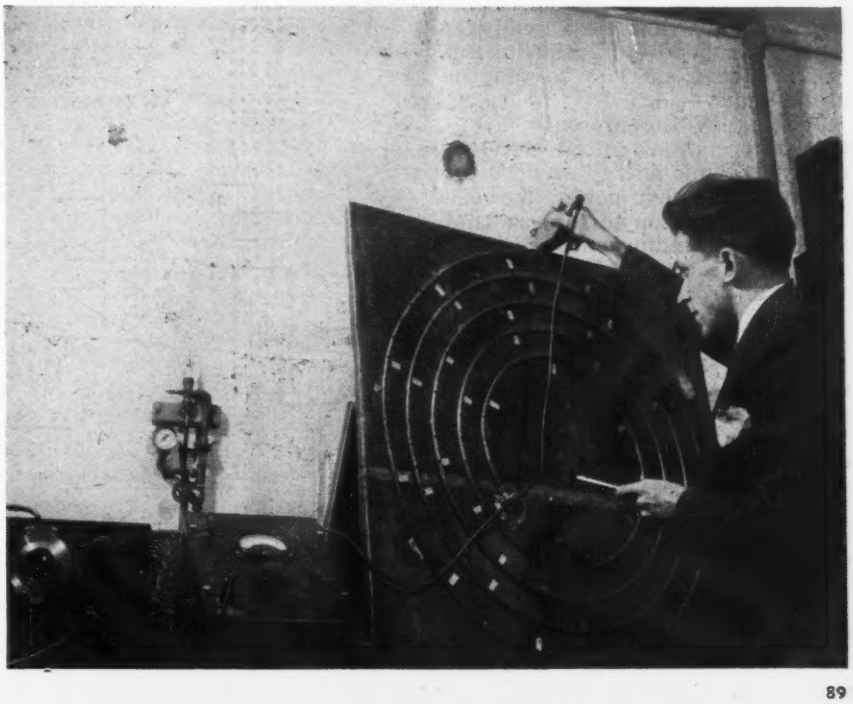


Fig. 2—Measuring section of co-axial feeder line consists of a wave length section with equidistant holes in the outer conductor to permit the measurement of voltage distribution. These holes are conveniently numbered 0, 1, 2, etc., starting at near end

GENERATION OF ATOMIC

By H. GREGORY SHEA,
Associate Editor, Electronic Industries

Electronic principles familiar to tube engineers are of vital importance in the development of nuclear energy

• Night and day at Hanford, Wash., next to the Columbia River, a number of self-generating chain reaction piles are producing large quantities of heat in connection with the transmutation of uranium into plutonium. For every gram of plutonium up to 1,500 kw hours of heat energy are produced and removed by the cooling action of the river.

This heat energy has been wasted and there were no attempts to harness it because effort was concentrated toward the single goal of producing an atomic bomb.

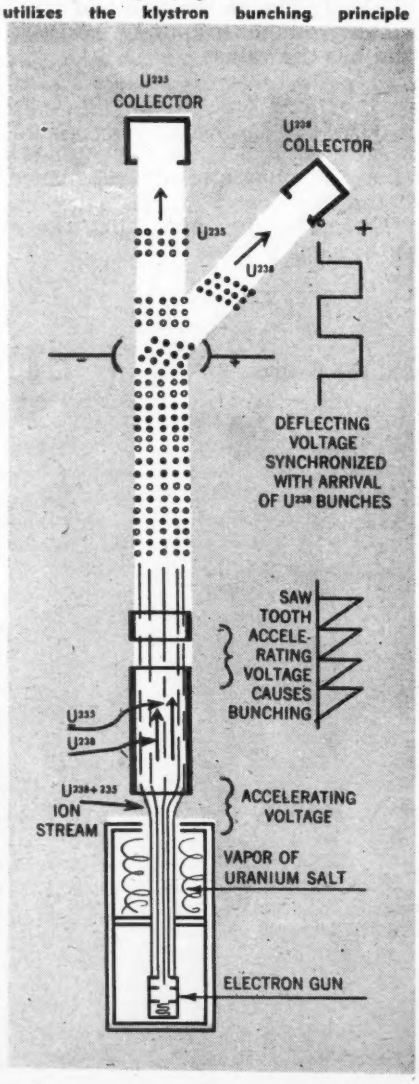
However, in the light of such production of energy from small amounts of material who can say that atomic power is not here!

Of course, there are engineering difficulties connected with using it. One obvious way of extracting the energy would be to reduce the flow of cooling water so that the temperature would rise to the steaming point. Possibly troubles would be encountered in this scheme. Doubtless, there is no demand for much power in that region of the United States so that an attempt to use it would prove uneconomic. The fact remains that here ready at hand is a means for utilizing nuclear binding energies to produce useful heat.

Judging by the presently available information, initial development of atomic energy would be as a primary source of power, like coal. There is no reason to suppose that shortly this binding energy can be applied directly to industrial and domestic processes without going through a series of complicated power plants any more than that coal could be so used. However, that need not worry us, since atomic power is undoubtedly here and may soon be ready to furnish electricity for our radios, our homes and our factories.

Modern nuclear physics postulates the atom to be made up of a nucleus bearing a positive electric charge surrounded by a system of electrons at various distances each bearing a negative electric charge of 1.60×10^{-19} coulombs. When the positive and negative charges are equal the atom is electrically neutral. The nucleus is supposed to be made up of one or more positively charged particles of matter called protons together with particles bearing no charge called neutrons. Since the proton has a mass of 1.6729×10^{-24} grams and the mass of the neutron is 1.6751, while the mass of the electron is 9.1067×10^{-28} grams it can readily be seen that as it takes about 1836 electrons to equal one proton, the protons and neutrons account for most of the mass of the atom. The mass unit used in physics is slightly different from any of these being equal to 1.6603×10^{-24} grams, or 1/16 the mass of an atom of oxygen in its most common form.

The Isotron, a promising but undeveloped scheme for separating U^{235} from U^{238}. It utilizes the klystron bunching principle



Hydrogen is the simplest atom known, having a nucleus consisting of only one proton with one electron surrounding it, while uranium until recently has been the most complex known atom having a nucleus consisting of 92 protons and 146 neutrons with 92 electrons surrounding the entire mass.

Atomic number

In writing nuclear equations the number of protons in a nucleus or, what is the same thing, the number of positive charges on a nucleus, is called the atomic number and is designated by the letter Z. The entire mass of the nucleus consisting of protons and neutrons designated by the letter A is called the mass number. The atomic number and mass number are written respectively as a subscript before and a superscript after the chemical symbol of the atom thus: $_{92}U^{238}$.

Since the diameter of a nucleus is about 10^{-12} centimeters while that of an atom is 10^{-8} centimeters, it can be seen that most space is empty.

Atoms having the same charge but different masses are called isotopes and in the last twenty years a very great number of these has been found. As they have identical numbers of electrons (equal to the number of protons) and as these appear to control the chemical behavior of matter, isotopes have the same chemical reactions. On the other hand, two different chemical elements having different charges may have the same mass and in such cases are called isobars.

Other particles mentioned in the literature are alpha particles which are helium nuclei containing two protons and two neutrons having

POWER FROM ELEMENTS

a charge of 2 and a mass of 4, beta rays consisting of a stream of electrons, gamma rays consisting of very short electromagnetic radiation similar to radio waves or x-rays, positrons which are positive electrons emitted by some artificial radioactive nuclei and deuterons which are nuclei of heavy hydrogen consisting of one proton and one neutron. Photon is the name used for a certain quantity of radiant energy.

Radioactive materials, or those bombarded by some kind of radiation, may give up various kinds of particles or radiation such as those listed above. The particles which have been found of such extraordinary use in the development of atomic energy have been the neutrons. As stated before, these are characterized by their lack of any charge. This permits them to proceed through matter unaffected by the intense electric fields surrounding the nuclei.

One of the important discoveries of physics has been that the sum of the masses of the protons and neutrons making up the nucleus of an atom is not equal to the mass of the atom nucleus. For example the total mass (in mass units of 1.6603×10^{-24} grams) of the components of the helium nucleus is

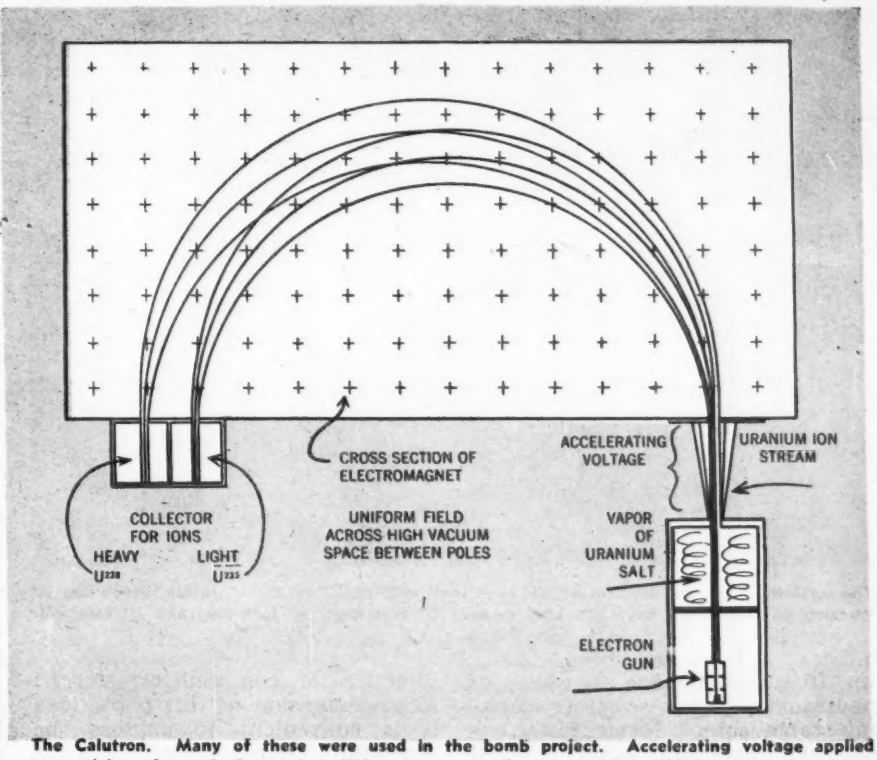
Protons	Neutrons

$$2 \times 1.00758 + 2 \times 1.00893 = 4.03302$$

whereas the mass of the helium nucleus itself is 4.00280. As can be seen the difference is equal to about .030 mass units.

A number of years ago through the work of Einstein and others it was discovered that the mass of a moving electron depended upon its velocity, and consequently classical force, mass, acceleration relationships must be modified when dealing with electrons or other atomic particles whenever their velocities begin to reach 1/10 or more of the velocity of light. For an electron such a velocity would be reached if it were subjected to an accelerating voltage of about 6,000 volts.

This discovery obviously indicated an equivalence between mass and energy. This Dr. Albert Einstein formulated in his equation $E = mc^2$ where E and m are energy and mass and c is the velocity of light. Thus multiplying .030 mass units (1.6603×10^{-24} grams) by 9×10^{20}, the square of the velocity of light one obtains 4.5×10^{-5} ergs per nucleus. Since there are 6.07×10^{23} molecules in a gram molecular weight this



The Calutron. Many of these were used in the bomb project. Accelerating voltage applied to particles of equal charge but different mass produces velocities differing by ratio $v/v_1 = (m_1/m)^{1/2}$. In the magnetic field the radii of motion depend on charge and velocity so that as a result they are in the ratio of $R/R_1 = \frac{mV/eH}{m_1V_1/eH} = mm_1^{1/2} / m_1m^{1/2} = (m/m_1)^{1/2}$

equals 2.7×10^{19} ergs per gram molecule of helium.

In other words we have reached the startling conclusion that a gram of helium has 188,750 kilowatt hours less energy than its individual protons and neutrons due to their association in helium nuclei. Since energy cannot be destroyed it must have been liberated during the combination. Hence, if we could find a way of combining protons and neutrons in free space into helium nuclei, we would presumably be able to generate such an amount of power for each gram of helium we made.

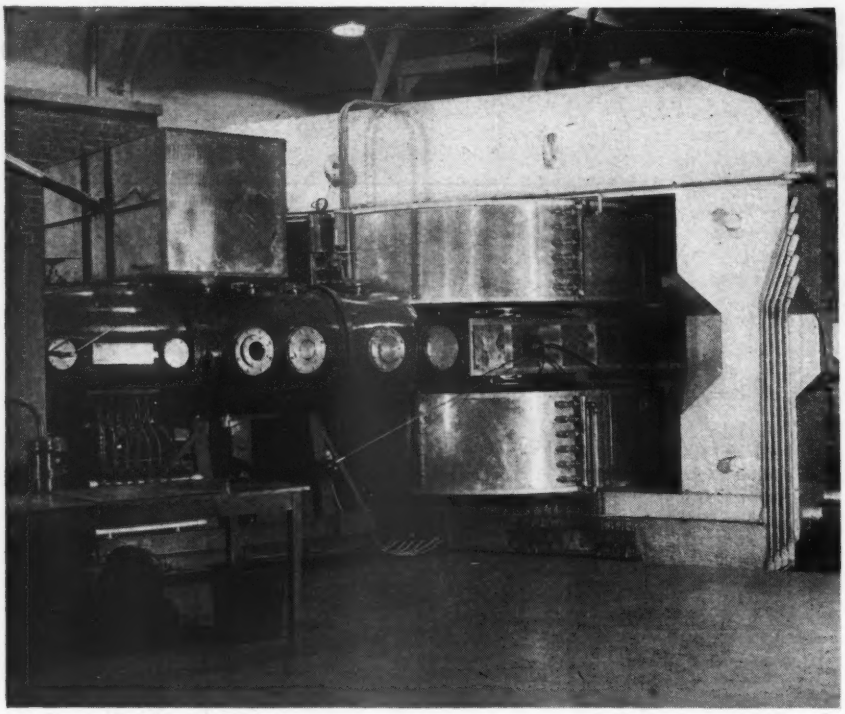
Binding energy

This energy is called the binding energy of the nucleus. As the binding energy per particle is calculated for various elements it is found that the elements in the middle of the periodic table having mass numbers ranging from 40 to 100 are most strongly bound, the energy decreasing toward the lower as well as toward the higher ends of the table. This suggests to the mind the possibility of obtaining energy either by breaking down heavy atoms or combining light ones.

Now both of these things actually have been done—at the lower end of the scale by bombarding a lithium target with protons to produce two helium nuclei each with an energy of 8.5 million electron volts, equal to 65,000 kilowatt hours per gram of lithium, and at the upper end by the breakdown or fission of U^{235} atoms into atoms of two groups of a number of other elements which shoot off at enormous velocities corresponding to an energy level of 200 million electron volts (Mev). It is the latter type of reaction, of course, that made possible the atomic bomb.

In 1940, A. V. Grosse of Columbia published a fission equation showing identification of the following elements in the fission products; molybdenum, iodine, xenon (4 isotopes), cesium (2 isotopes), lanthanum and cerium. Masses ranged from 127 to 140 in the iodine-cerium group and around 92 for the light group.

The variety of products is apparently due to the fact that the ratio of neutrons to protons is greater in the very heavy atoms than in the middle range ones. Therefore two lighter atoms result-



The cyclotron at the department of terrestrial magnetism of the Carnegie Institution of Washington. It weighs over 225 tons, is over 12 feet high, 30 feet long and 20 feet wide

ing from fission have an excess of neutrons to dispose of before reaching stable isotopic forms. These excess neutrons can be either emitted or can become protons if an electron is emitted. In the breakdown of uranium there is a considerable number of excess neutrons available. The products of breakdown are the results of the various possible combinations obtained by neutron or electron emission.

The neutrons which are used to initiate the breakdown of uranium can be obtained by the bombardment of certain elements such as beryllium or boron by natural alpha particles. A common means of doing this is to use a mixture of radium and beryllium, the alpha particles of the radium penetrating the Be^{9} nuclei. These then give off neutrons and become stable carbon (C^{12}) nuclei. There are a number of other reactions that could be used for the same purpose.

Capture probability

We have seen above how small the nuclei are in comparison to the space occupied by atoms so that it becomes important to consider what chance a stream of neutrons has of hitting atomic nuclei in its passage through target material. This is a statistical question which can be resolved by well-known methods of geometrical probabilities and depends on the number of atomic centers in an area of a plane perpendicular to the direction of the neutron stream. As an extension of this plane idea it is convenient to express the probability that a particle will hit such a target in terms of a cross-section. This cross-section in square centimeters is defined as the ratio of the number of processes occurring to the product of the number of incident particles and the number of target nuclei per square centimeter. Such cross-sections vary enormously depending on the materials and on the impinging particles, as much as from $1{,}000 \times 10^{-24}$ cm^2 down to $\frac{1}{1{,}000} \times 10^{-24}$ cm^2.

Ordinarily uranium is predominantly the $_{92}U^{238}$ isotope containing about one part in 140 of $_{92}U^{235}$. As previously stated $_{92}U^{235}$ can be broken down with the release of tremendous energy. However, when U^{238} is bombarded with neutrons it does not break down but produces $_{92}U^{239}$ plus gamma rays. $_{92}U^{239}$ transmutes into neptunium $_{93}Np^{239}$ with the emission of one electron, the half life of this process being 23 minutes. In turn $_{93}Np^{239}$ transmutes into plutonium, $_{94}Pu^{239}$ with the emission of one electron and gamma rays in a half life period of 2.3 days. Like U^{235}, Pu^{239} is subject to fission when bombarded by neutrons. Also like U^{235} it releases about the same amount of energy.

With this background of information it can easily be seen that if a substantial amount of either U^{235} or Pu^{239} could be obtained and could be caused to break down rapidly, an explosive action would result and that the energy release of 200 Mev would be equal to 23,000 kwh per gram of substance exploded, or about, 3.57×10^{10} Btu/lb. Even if only 1/10 of 1 per cent of the energy were released before the bomb flew apart and the reaction stopped this would amount to 36 million Btu per pound of substance. Assuming that the specific heat of the exploding material were 1/30 that of water the temperature rise due to the transformation of that amount of energy into heating a pound of material would be one billion degrees F, an almost inconceivable temperature.

Chain reaction

The question that immediately arises in an engineer's mind is that if all these figures are true, how can there be any uranium left in the world. In other words, why hasn't all of it disintegrated long ago? This immediately brings up the question of chain reaction. If an ordinary combustible substance such as a piece of paper is ignited with a match, heat generated by the burning of the paper at any one spot is sufficient to ignite the paper all around that spot and so the process of combustion goes on until all of the paper has been burned. All of us, however, have had the experience of trying to light a fire in the fireplace using heavily coated magazine paper and have found that often after being started it would go out due to the large amount of non-combustible material present.

It is the same way with uranium occurring in nature. The amount of fissionable material is so small a proportion of the entire quantity of uranium that a chain reaction cannot proceed and the neutrons produced by fission do not produce enough secondary fissions to keep the process going. In order to have a chain reaction it is necessary that the ratio of fissions produced secondarily to those produced primarily be greater than 1. If this ratio is less than 1 fission will die out. Now neutrons may be dissipated in four different ways:

(1) They may escape out of the material entirely.
(2) They may be captured by the uranium in a manner not producing fission.
(3) They may be captured by impurities.
(4) They may cause fission.

Naturally, whether a ratio or multiplication factor greater than

1, as mentioned above, can be maintained depends on the frequency of occurrence of these various means of dissipation of neutrons. The escape ratio naturally depends on the relation between the surface of the active material and its volume and hence there is a critical size which will permit a chain reaction to exist and below which none can take place.

Non-fission or so-called resonance capture of neutrons by uranium atoms generally occurs when neutrons have a speed higher than that for which fission capture occurs. Since fission itself produces high speed neutrons which are ineffective in causing further breakdowns, they must be slowed down, but in slowing down they must pass through the middle speed range. In order to slow down the neutrons efficiently it is desirable to make them pass through a retarding or moderating material. This should have a low atomic weight because in elastic collisions the ratio of energy carried off by light and heavy particles is inversely proportional to the masses involved. For this purpose carbon in the form of graphite has been used.

Graphite pile

It can be shown by calculation that the number of medium speed neutron collisions can be reduced more by having lumps of uranium separated by the graphite rather than by having an intimate homogeneous mixture of uranium and graphite. Furthermore, since U^{238} has a large capture cross-section for medium speed neutrons, producing U^{239} but not fission, it wastes neutrons, and it seems obvious that by separating U^{235} from U^{238} and discarding the latter, a chain reaction might be set in motion.

In producing the atomic bomb both U^{235} and Pu^{239} were made so that no possibility of success might be overlooked.

The Pu^{239} manufacturing process at the Hanford Plant in Washington near the Columbia River embodies the principle of a controlled chain reaction occurring in a pile consisting of graphite interspersed with uranium. The first model of such a chain reaction pile was built in a rough spherical form somewhat like a door knob. It consisted of graphite bricks built up in layers, alternate ones of which contained lumps of uranium at the corners of squares. It had about 12,400 lb. of metal altogether and for control purposes had ten slots passing completely through it. One row of bricks was arranged so that it could be pushed completely out of the pile. Control was obtained by rods of boron steel having a high neutron absorbing capacity placed so that they could be pushed in and out of the control slots. A multiplication factor of 1.0006 was obtained with this pile and while at first it was operated at a power of ½ watt this was later increased to 200 watts, a limit caused by the danger of radiation of the radioactive substances to the street. (The pile was in the West stands of the University of Chicago stadium.)

Since the production of one gram of plutonium per day results in the liberation of energy at the rate of 500 to 1,500 kilowatts it is apparent that very expensive cooling facilities would be required for large scale production.

Pilot plant

To facilitate study of problems in connection with handling of substantial quantities at Hanford, a pilot plant was built at Clinton, Tennessee. Instead of having the uranium formed in lumps, in this case the pile consisted of a cube of graphite containing horizontal channels. Uranium in the form of metal cylinders protected by gas-tight casings of aluminum were placed in these channels and cooling air was forced through the channels.

After the reaction has been going on for a certain time the cans containing uranium are pushed out of the pile and chemical separation of the plutonium proceeds. The means used to separate out the Pu involved the phenomenon of coprecipitation, i.e., the precipitation of small concentrations of one element along with a carrier precipitate of some other element.

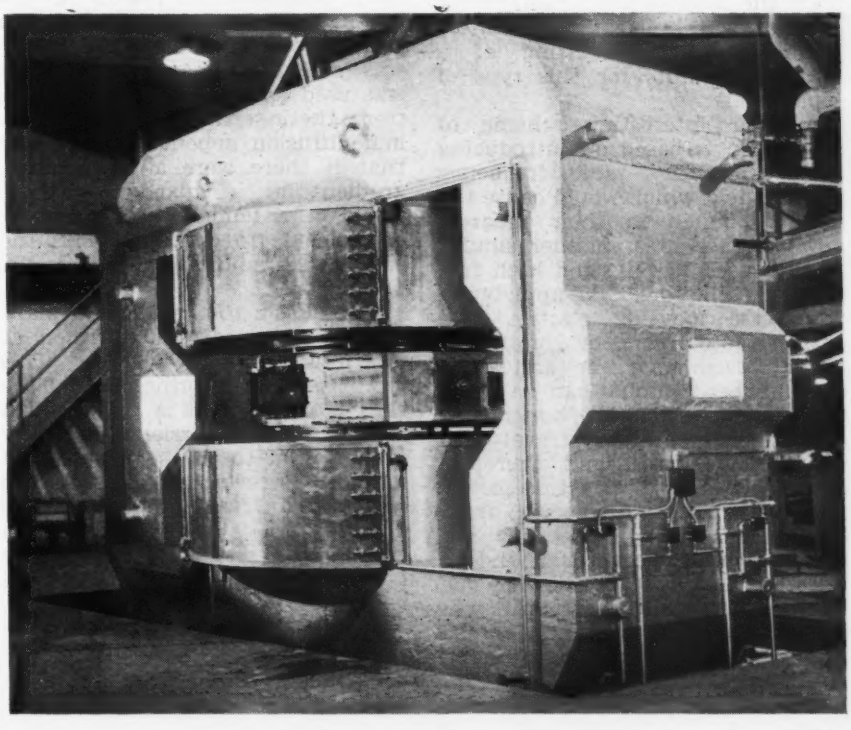
U^{235} separation

The success of the separation process at Hanford has exceeded all expectations and it is interesting to note that the process was developed from a knowledge of plutonium chemistry gleaned from less than a milligram of the material.

As stated above, at the same time that work on plutonium was progressing, investigations were carried on to determine a method of separating U^{235} from U^{238}. Two general methods of separation have been used, the electromagnetic method and the diffusion method. The electromagnetic method made use principally of what came to be called a "calutron" which name is a contraction of California University's cyclotron. Briefly the principle of the calutron consisted of producing positive uranium ions, accelerating them into the field of a very powerful electromagnet which causes them to move in a circular path and collecting them after they have traversed a semicircle. The separation between U^{235} and U^{238} depended on the fact that one of them having a slightly greater mass would move in a semi-circle of greater radius than the other.

By placing suitable collectors at the termination points of these

General view of a cyclotron. The cast steel pole structure, field coils and magnetic gap may be seen. Applied to "Calutron" use, the gap is evacuated to permit movement of ions



semi-circles of different diameters, the separate isotopes could be caught. The ions were produced by shooting a beam of electrons through the vapor of a uranium salt and permitting the resulting ionized uranium particles to go through a slit and through an electric field which accelerated them. It can readily be seen that ions coming out of the slit would initially be moving in slightly different directions, the total dispersion angles depending on the width of the slit. All ions of equal mass, however, would move in semicircles of the same diameter and therefore after completing a semicircle they would re-converge so that the logical place to put the collector was at the re-conversion point.

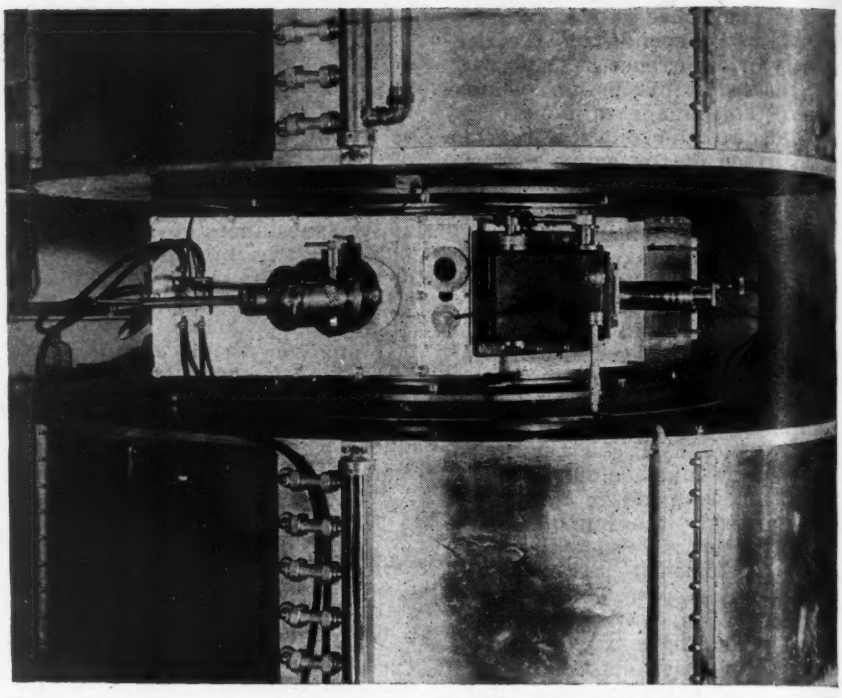
Cyclotron magnet

This electromagnetic separation method immediately produced greater concentration than gaseous diffusion methods and work progressed on it energetically. There was available at Berkeley a giant cyclotron magnet with a pole diameter of 184 in. and a gap of 72 in. which was to be the largest in existence. Its completion had been interruped because of the war and therefore it was available for dismantling and use in this electromagnetic separation scheme. Much work resulted in a great increase in the beam strength of the ion. The width of the slit was increased to permit more ions to go through and magnetic focusing methods were used so that the dispersion would not be too great.

On the basis of the Berkeley work a plant was built at the Clinton, Tennessee, site consisting of a number of units for this type of separation.

Another interesting scheme of separation is based on introducing a low intensity radio frequency electric field which would cause the ions to bunch in their progress down a tube in a manner similar to that used for klystron high frequency oscillators. By applying a transverse focusing electric field with a radio frequency component synchronized with the arrival of the bunches, isotopes can be separated inasmuch as the bunches of ions of different mass travel with different velocities and therefore became separated. By this means U^{238} ions can be deflected from the stream whereas the U^{235} ion bunches can come through and be selected. Although this scheme held great promise, work on it was discontinued to permit more attention to be given to the calutron method.

Of course, in the electromagnetic method of separation of the isotopes, a balance had to be struck between the yield per stage and the purity obtained per stage. If the purity were run up, the yield of course went down, so that finally a large number of stages were built.



Close up of target and accelerating chamber of the Carnegie cyclotron. In using these for uranium isotope separation, a number of modifications had to be made. Main magnets were kept

Gaseous diffusion

It was recognized early that if the raw materials could be enriched even by a slight amount, an enormous benefit would result. In order to do this a thermal diffusion plant for the separation of isotopes was constructed and its product was used as a feeder for the electromagnetic separation plant. Thermal diffusion depends on the fact that if there were a temperature gradient in a mixed gas there would be a tendency for one type of molecule to concentrate in the cold region and the other in the hot region.

In addition to the above a plant was built for gaseous diffusion at Charlotte, North Carolina. This was based on the principle that the rate of diffusion of a gas through an ideal porous barrier is inversely proportional to the square root of its molecular weight. Thus if a gas consisting of two isotopes starts to diffuse through a barrier into an evacuated vessel the light isotope diffuses more rapidly than the heavier.

In conclusion, a word should be said about the production of the bomb itself. From what has gone before it is obvious that a certain minimum size was required for the reaction to proceed. This suggests a means of keeping the bomb inactive until the correct moment by keeping pieces of the reactive material separated from each other and bringing them together with great rapidity at the time of detonation. This could be accomplished by firing one of the portions of the bomb against the other portion to detonate the bomb. In addition the bomb would have to be enclosed in an envelope which reflected many neutrons back into the reactive material and which would have a high inertia, thereby delaying the expansion of the reactive material inasmuch as fission takes place in 10^{-12} seconds.

Air-borne Radio Station

Army communication units established radio contact with Manila only 45 minutes after American troops landed on Japanese soil. The contact was established by a high power station which had been built into twelve transport planes and flown to the Atsugi airfield with advance units.

The station was constructed on 42 hours' notice and was comprised of four three kw transmitters, five 800-watt transmitters, and four jeep-mounted control towers. Besides being used for Manila contact, the station was also set up as a navigational direction aid for approaching aircraft.

Thru the LABORATORY KEYHOLE

Current Research that Forecasts Future Electronic Developments

3000 MC OSCILLATOR—Certain financial interests are said to be negotiating with an inventor who has developed a means of producing 3000 mc oscillation with an ordinary receiving tube. The scheme is supposed not to depend on the ordinarily limiting tube constants such as inter-electrode capacitance.

CANDLELIGHT TELEVISION was actually demonstrated as a possibility of the new supersensitive video pickup —indicating that postwar television will no longer require studio intensities of hundreds of foot-candles. A visiting group saw a television scene illuminated only by one candle! And the pickup was excellent.

RETINA SENSITIVE TO UV—At Harvard biological lab, Dr. George Wald in experiments with persons whose eye lenses have been removed in cataract operations, finds that the human retina, freed of its lens filter, is highly sensitive to ultra violet or 'black light." At 365 millimicrons, this average sensitivity of lensless eyes is 1000 times normal. In fact, under black light which made the room Stygean-dark for normal eyes, 60-70 year old patients read a test chart top to bottom.

BRITISH STUDY FOLIAGE SHIELDING—Regarding recent articles on the subject of foliage shielding at television and FM frequencies, the British have recently completed some very thorough engineering measurements on the effect of leaves on UHF, continuing these studies up to centimeter waves. This information should be released for publication within six months.

KRYPTON ONE-TENTH-WATT LAMPS, which have been developed in Westinghouse laboratories at Bloomfield, N. J., offer many new applications for pilot lamps, instrument boards, clock and dial illumination. These little KR-110 volt fluorescent lamps, containing double spiral electrodes, glow with yellow-green light at the maximum sensitivity of the human eye. They are rated at 3000 to 5000 hours' life, so that for many uses they will be burned continuously.

SOUND AT 30,000 FT.—The jet plane which flew from Dayton to New York in an hour, was announced to have a speed of 550 miles per hour, nearly the "speed of sound". At 30,000 ft., the plane's usual height, sound has a speed of 680 miles per hour, compared with 750 miles per hour at sea level.

PISCATORIAL ELECTRONICS—Laboratory tests underway indicate that elimination of bad odors from fish reduction plants by drying the fish meal with heat from infra-red lamps may enable the plants to be more conveniently located for reception of raw material and shipment of finished product. Furthermore, schools of fish can be located by means of under-water sound detectors instead of depending upon the sheen they cause in the water. Finally, Pacific Coast canneries are also experimenting with high-frequency cooking in glass jars.

RED POINTS FOR LAB WORKERS—Dr. Irving Langmuir, who has just returned from a visit to Russian laboratories and research institutes, reports that Soviet scientists and laboratory workers are, as a matter of governmental policy, regularly rewarded with extra ration allowances as well as money. Since such rationed goods, including food, furniture and clothing are sold at pre-war prices, while unrationed goods carry a surtax as high as 99 per cent, money is of little importance in the present economy of the Muscovites.

OLD CHINESE CUSTOM AIDS RADAR—In China for ages, prisoners have been restrained by simple woven sleeves placed on their arms. If they try to pull away, the woven sleeves are drawn tight and grip more firmly than ever. Later this idea was imported to America and used as a cable-grip for drawing cables into conduits. And now the Signal Corps has applied the pull-grip to removing radio and radar tubes from their sockets, when the pulling is hard. Several thousand Kellems grips have already been purchased for this purpose.

SIMPLICITY IN CHANGERS—New Erwood record-changer reported from Milwaukee to have only four moving parts. Finished laboratory models are now being advanced to be made ready for production schedules running several thousand per day.

NOTE: *Please don't ask us for more details about any of the foregoing. We present here all the information we have. As soon as we get more about any of these situations, full details will be printed in Electronic Industries. Our editors run across many interesting tips, leads, and rumors, both well-founded and baseless. We thought you would be interested in hearing about them, even if we can't give all the details or vouch for their authenticity. Editors.*

CENTRALIZED LABORATORIES FOR BASIC RESEARCH

Formerly it was the practice of large corporations to have research for their various departments and subsidiaries done in scattered local laboratories under the direction of each division. Now a change is taking place in the direction of having all basic scientific research concentrated in a principal research laboratory, while subsidiaries tackle only immediate product research. This newer policy is evident in GE's retention of basic electronic research at Schenectady, despite its plans for a great electronic center at Syracuse. Also, RCA's Princeton, N. J. laboratory layout, follows this principle, as will General Motor's new $20,000,000 research center near Detroit.

More and more, parent corporations will insist on keeping in their own hands all basic research of their fields.

PRACTICAL PROBLEMS OF

By C. W. FRANKLIN,
Cambridge Thermionic Corp., Cambridge, Mass.

A systematic approach to methods that will result in reducing differences under conditions otherwise standard

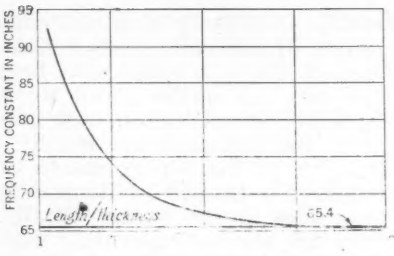


Fig. 1—Length/thickness vs. frequency constant for AT cut crystals

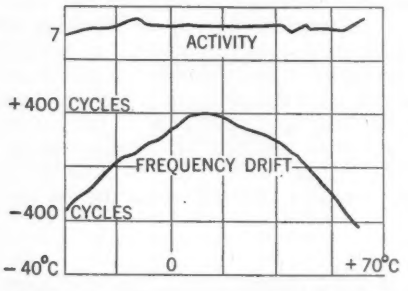


Fig. 2—Activity-temperature and frequency-temperature for well-mounted, well-dimensioned BT crystal

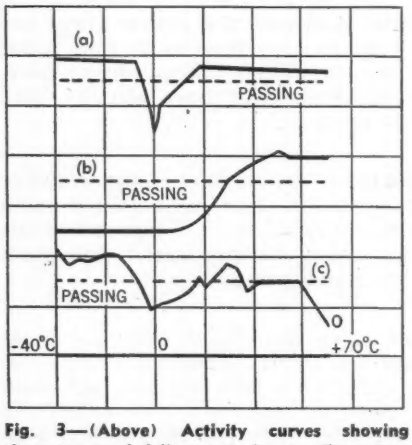
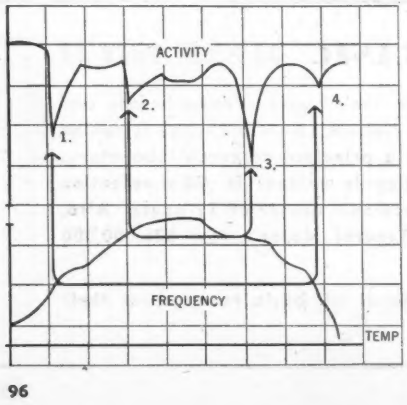


Fig. 3—(Above) Activity curves showing three types of failure not due to dimensions

Fig. 4—Badly dimensioned crystal, exhibiting sawtooth at critical frequencies



In the manufacture of quartz crystal units as in all other branches of the electronic industry the impatient and exaggerated demands of the war years have forced development. Problems which defied theoretical solution have had to be tackled practically and have somehow been solved. Furthermore a vast amount of material has passed through critical fingers and yielded up new knowledge. Thus we are now in a position to do many things that we could not have attempted before, and to advance even further in others.

• What remains to be done in the crystal field lies in the direction of the standardization of electrical and mechanical characteristics. Crystals of a given cut and frequency should not vary as much with respect to resistance, inductance, capacity, activity and frequency drift, as is commonly the case. Since tolerances and technics in the matter of cutting, lapping, finishing and mounting are accurately prescribed, this divergence must proceed from some other source.

It has been observed that in "thickness" crystals certain face dimensions are extremely favorable to desirable behavior and certain others extremely adverse. Some sort of dimension control is, therefore, called for. Unfortunately, there is as yet no complete body of information on the vital question of dimensioning. It is the purpose of this paper to offer a systematic approach to the subject.

Let me specify what is meant by dimensioning. Every crystal when finished has one dimension which is thought of as governing its frequency, which is determined as the ratio of a certain constant K (the frequency constant) and this dimension, i.e. $f = \frac{K}{t}$. If this were literally the case then problems of dimensioning would not exist. It would merely be necessary to assign the determining dimension in such a way as to obtain the desired ratio, and the desired frequency would result.

But it must be always kept in mind that, despite its usefulness in electric circuits, a piezo-crystal is primarily a vibrating solid. As such it is subject to the mathematical laws of elasticity in which boundary conditions are vital. Hence, a change in any one of its dimensions may well affect all its modes of vibration. Thus when we are concerned with the frequency of a plate in its thickness mode of vibration, we may not a priori assume that thickness alone is the determining factor: all of its dimensions affect it.

That this last statement is so may be readily verified: A thickness vibrating crystal (AT or BT) is systematically altered by progressive reduction of its length (or width). Its frequency as read with a deviator is recorded with successive values of the dimension under consideration. It is then seen that the frequency is seldom twice the same: That changes of .002 in. may be accompanied by changes of ±300 cycles or more and that the overall trend for substantial reduction in surface area is always a substantial increase in frequency. Thus the thickness which has been left unchanged throughout is not the unique determining factor.

Mathematics is corroborated by practice in finding this phenomenon to exist. Unfortunately mathematics fails us at this point: It states the difficulty but does not offer the cure. The problem of the finite vibrating plate is incompletely solved, and if our knowledge of its behavior is to be made more precise we must rely on experimental methods. From cumulative experimental data we must seek to discover what choice of crystal dimensions for a given cut leaves the mode of vibration in which we are interested at any time most immune to changes in the

CRYSTAL DIMENSIONING

other modes. This is the problem of dimensioning.

Theoretical approach

As indicated, because of coupling with other modes the so-called frequency-constant is not constant but varies inversely with length/thickness ratio. Bechmann* has developed a curve relating the thickness frequency-constant given in mm. for circular AT crystals to the diameter/thickness ratio. The accompaning curve (Fig. 1) gives such data for measurements in inches. The straight line in this diagram represents the thickness/frequency constant, K = 65.4, for the same cut calculated mathematically on the assumption of no coupling (infinite plate) from the elastic constants of quartz.

On the assumption of uncoupled vibration, it is possible to calculate ideal frequency constants for the various other vibratory modes. A whole school of dimensioning is based on the frequency constants for these uncoupled modes. These constants determine a set of secondary frequencies and their overtones. If any one of these frequencies (or of its overtones) coincides with the frequency of the desired mode of crystal vibration, it is likely to cause bad or uncertain performance. If, therefore, dimensions for which this can occur are calculated and avoided by as wide a margin as possible, it is not unreasonable to expect that good performance will result.

In fact, if crystal modes of vibration occurred simultaneously in their uncoupled form, this would be an infallible method of dimensioning. But, as we have stated, the finiteness of the plate introduces unpredictable interaction between the various modes. The uncoupled modes with their predicted frequencies do not necessarily occur. And even if a predicted frequency is present, we may not, without elaborate interferometric study, presume that it is due to a specified mode. Thus, although the theoretical approach to crystal dimensioning is valuable as a first approximation, it must still be subjected to experimental verification.

Nevertheless we may not decide that because it is difficult to pin down the laws of crystal behavior in terms of mathematical formulas and physical nomenclature, such laws do not exist. Crystal phenomena are consistent and recurrent and may be studied accordingly.

It is important to emphasize at this point that no analysis of crystal behavior can be fruitful unless the crystals under scrutiny and those to which we hope to apply our conclusions are kept within close tolerances of the same cutting angles. It is only under these circumstances that we may state that crystals cut to the same dimensions, mounted in the same way and finished to the same frequency at room temperature give closely similar results.

Frequency and activity

Under government specification all crystals are called upon to pass certain continuous temperature change tests. Frequency and amplitude of vibration, or "activity," (measured in terms of rectified grid current) are recorded over a range from —40 deg. C. to +70 deg. C. or greater. Under these tests crystals are acceptable if their activity stays in excess of a preassigned minimum and their frequency drift lies within a preassigned maximum.

A satisfactory pair of activity and frequency curves for a BT crystal is given in Fig. 2.

Frequency has it peak value at the mid-point of the temperature range and falls away parabolically on either side in a rather shallow curve; activity is high and smooth.

Often, however, the recorded crystal makes no such showing but produces simultaneous irregularities in both curves. These irregularities are capable of diagnostic interpretation.

As it is, in particular, the correlation between curve irregularity and bad dimensioning that interests us, other sources of curve irregularity must be carefully eliminated. A crystal will give eccentric performance if it is chipped, flawed, dirty or wet, if it is subjected to unfavorable pressure, or if its air-gap is of the critical height given by integral multiples of

$$h \text{ (in inches)} = \frac{792 \times \sqrt{\text{absolute temperature}}}{2 \times \text{frequency in cycles}}$$

This is the height for which the air gap resonates at crystal frequency and may beat heavily against it and damp it. Since the numerator of the fraction increases steadily with temperature while the denominator changes negligibly, we may expect this phenomeon to

(*Continued on page* 146)

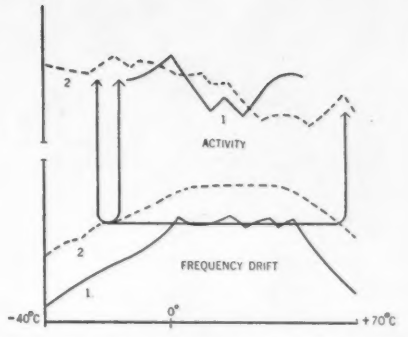


Fig. 5—Air gap unchanged, crystal unchanged. Note recurrance of instability near same frequency

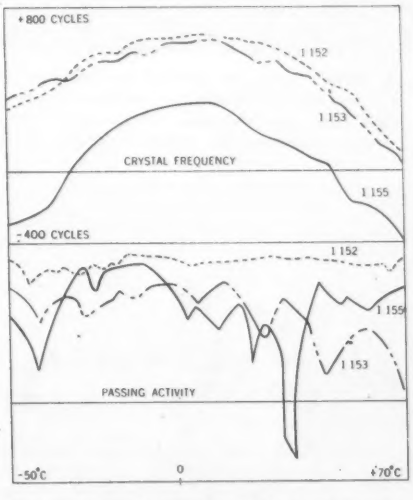


Fig. 6—(Above) Result obtained when electrodes and mounting are unchanged but one dimension is changed progressively

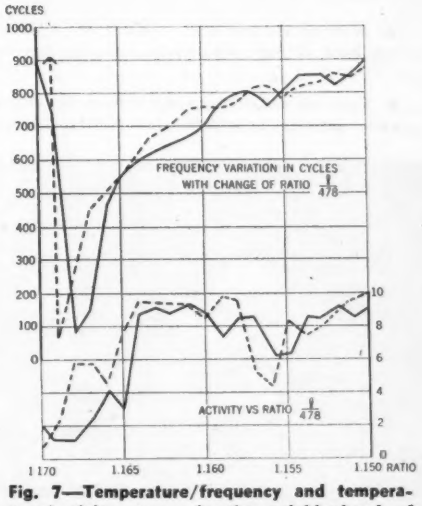
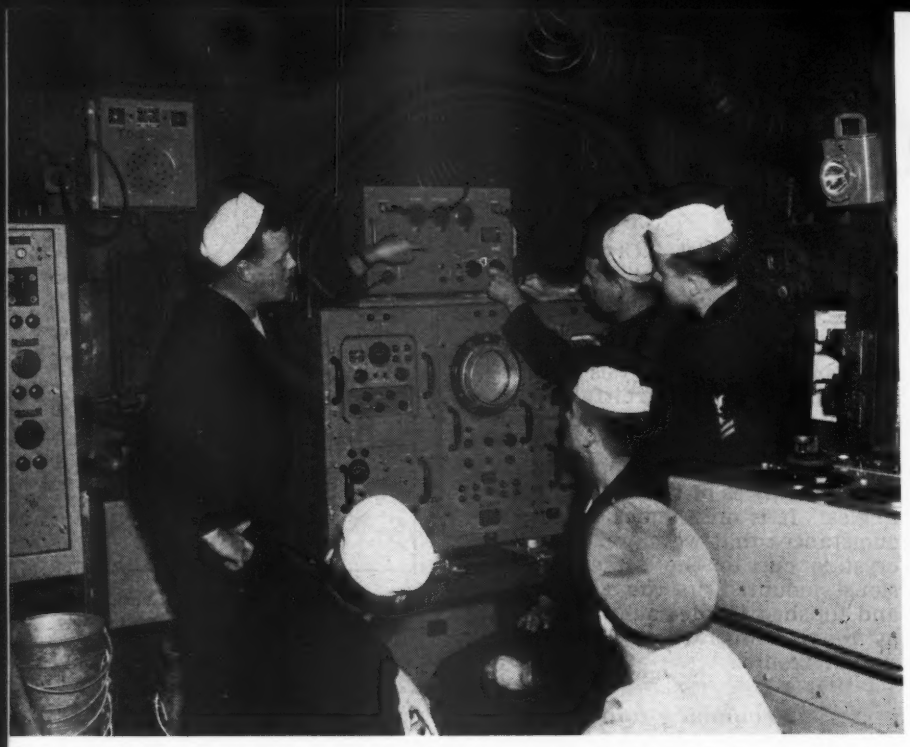


Fig. 7—Temperature/frequency and temperature/activity curves in the neighborhood of desirable dimensions for BT cut crystals

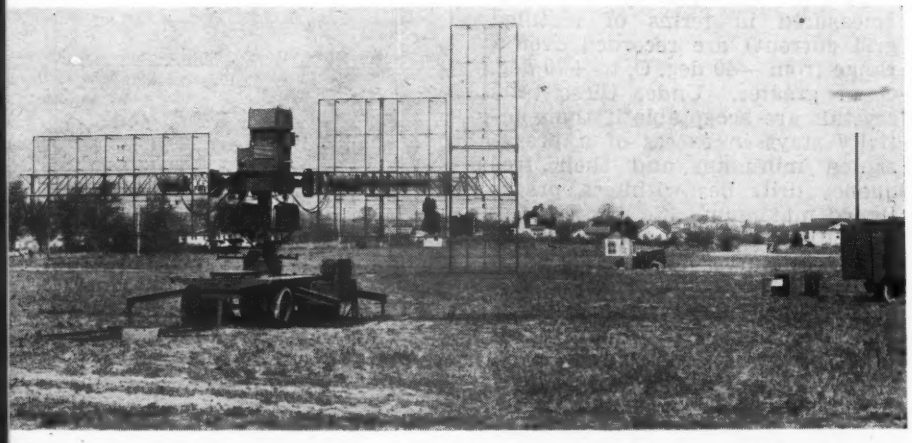
*R. Bechman, Hochfrequenztechnik und Electroakustik, Band 59, Heft 4.

ARMY and

Electrical echoes can be in either horizontal and



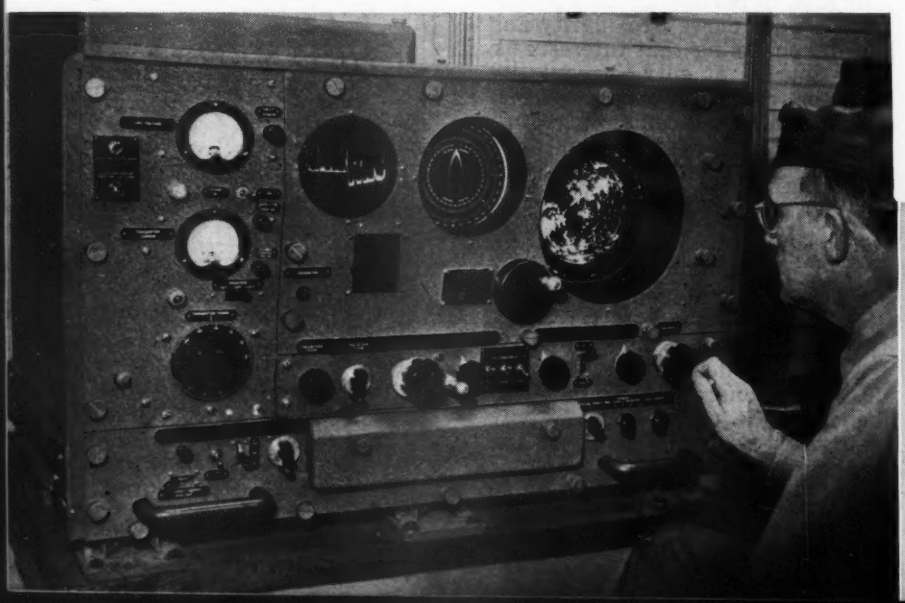
▲ Modern radar set installed on shipboard. Plan position indicator tube is at center. This gives a radial picture of the surroundings of the set location. The sweep starts at the center of the CRO tube face and goes to the outer edge. As the antenna is turned in azimuth the sweep rotates synchronously. Echoes intensify the beam of the CRO tube. This creates a bright spot



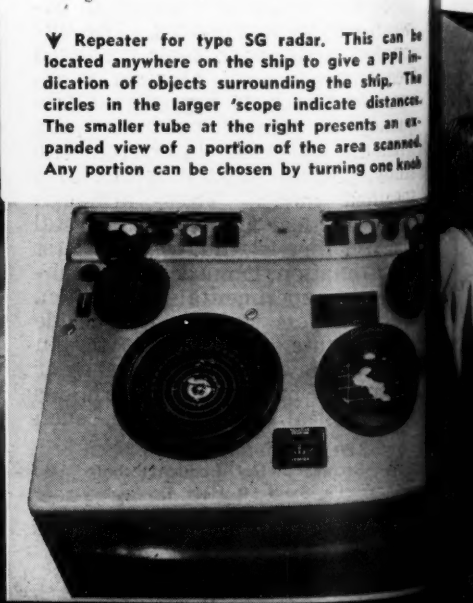
▲ Western Electric early warning radar set which made the sound locator obsolete. This model was built of light magnesium and was mounted on a wheel truck for mobility and erection ease

Many types of radar sets have been used by the Army and Navy during the war and doubtless several types will find application in peace time. The word radar refers, not to a particular instrument, but to the general system of sending out hf pulses and measuring the direction from which an echo is received as well as the time interval between sending the pulse and receiving the echo. Not only is it possible to reproduce the information obtained in a number of different ways, but also various operating frequencies can be used for different purposes. For example, if the whole sky is to be searched for planes it would be foolish to use an extremely sharp and narrow beam possibly ½ deg. wide and enclosing a solid angle of only 6.28×10^{-5} steradians since such a long period of sweeping would be needed to cover an appreciable area of the whole outdoors. Therefore, so-called early warning sets are made to operate at the reasonably low radar frequencies of 200 mc and are supplied with large bedspring type antennas as shown on this page. These not only send out a beam of respectable width but also present a substantial collecting surface for the echo energy. On the other hand, when it is desired to pin-point a known target for gun-

▼ Type SG radar displaying echoes on horizontal line (type A) (left) and radially (PPI) (right). Vertical lines in type A presentation are echoes while distance from left edge indicates distance from ship. Dial in center shows ship's heading, true compass points and direction of antenna



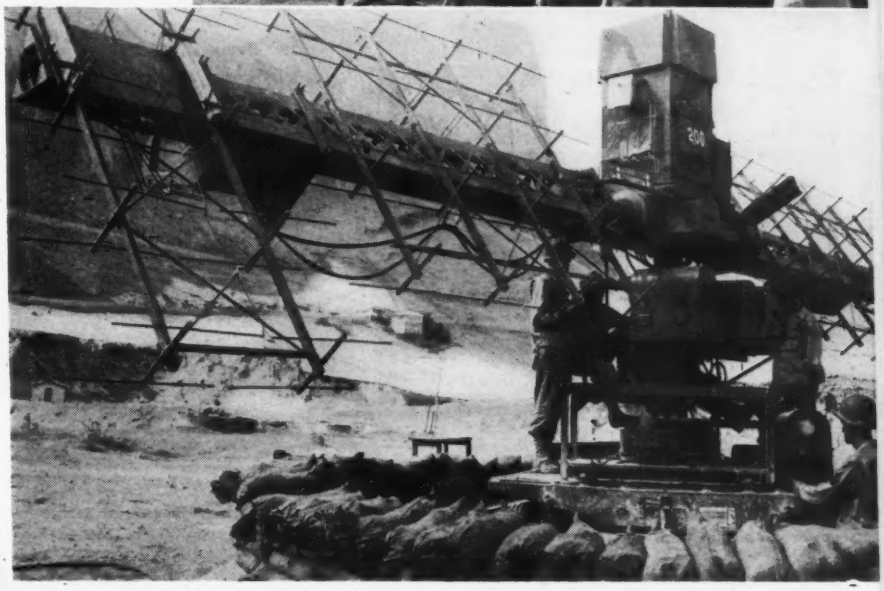
▼ Repeater for type SG radar. This can be located anywhere on the ship to give a PPI indication of objects surrounding the ship. The circles in the larger 'scope indicate distances. The smaller tube at the right presents an expanded view of a portion of the area scanned. Any portion can be chosen by turning one knob



NAVY RADAR

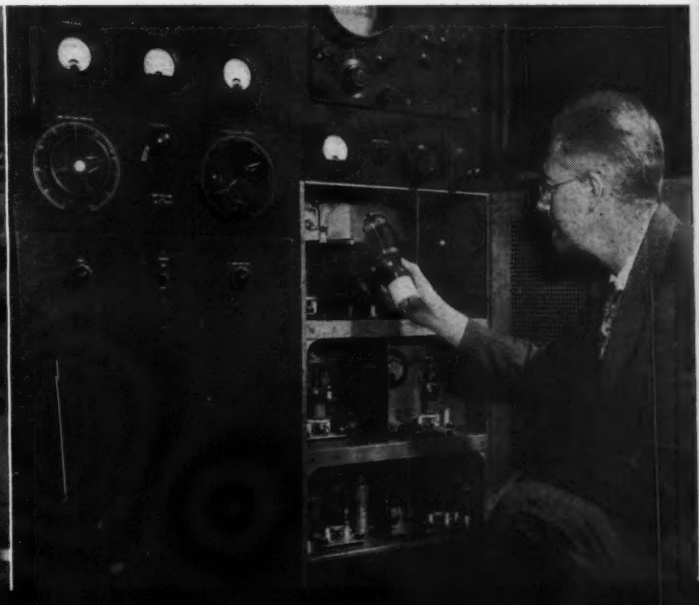
shown on oscillograph tubes
vertical or circular patterns

fire ranging purposes a sharp accurate beam is highly desirable, giving accuracy greater than that of the dispersion of the shells themselves. Aside from the PPI presentation, CRO tubes can be used to show range only along a horizontal axis, or azimuth angle horizontally and elevation angle vertically. In some types of radar sets, notably the earlier ones showing only the range along the horizontal axis, the distance was marked right on the face of the tube by means of a calibrated scale. Later models contain a step or notch, part of the trace being displaced vertically by means of a dc voltage impressed on the deflector plates at the proper instant of time in the transmission-echo reception cycle. The beginning of this step can be moved left or right by a hand knob until it corresponds to the echo pip of interest at the moment. Previous calibration permits the knob to actuate geared dials reading distance accurately. Such a step is shown on the 'scope face on the opposite page. Other schemes used are the inclusion of markers along the trace. These are pips formed by the discharge of condensers at accurately known time intervals in so called counter circuits. Usually several sets of markers are available by turning a switch. These correspond to several sweep speeds permitting one instrument to be used for either long or short range work.



▲ Numerous antennas on this fighting mast testify to the importance of radar. Two bedspirng types can be seen as well as a semicylindrical reflector. Below, early warning set used in Italy

▼ Range in yards can be read on dials below the type A 'scope face at the right while true and relative bearings show on an indicator above the right hand. Dr. R. M. Page at the right is holding a rectifier tube from an early XAF radar now honorably retired from the fleet



ENGINEERING DETAILS

By HUGO ROMANDER
Federal Radio and Telephone Corp., Newark, N. J.

Technical data and constructional features of fully modulated inverted amplifier operating at 6-22 mc

● Two of the most powerful short-wave broadcast stations in the world, strategically situated near the West Coast where coverage of the western Pacific area can be made more effective than from any other region of the continental United States, are now in operation, carrying both morale broadcasts by the Armed Forces Radio Service to our troops in that theater, as well as an intensive OWI campaign of psychological warfare to Japan. Designed and equipped by the Federal Telephone and Radio Corp. to meet specifications of the Office of War Information, these stations are part of the OWI program.

The recently completed stations are located at Delano, near Bakersfield, and at Dixon, near Sacramento, California. Construction of the building and installation of primary power supply and audio equipment at Delano has been supervised by the Columbia Broadcasting System,* while the National Broadcasting Company has similarly participated in the construction of the Dixon station. Federal Telephone and Radio Corp., associate of the International Telephone and Telegraph Corp., has supplied and installed, in addition to the 200 kilowatt amplifiers, the 150 kilowatt modulators, and all associated rectifier and power supply equipment, including the cooling-water circulation system.

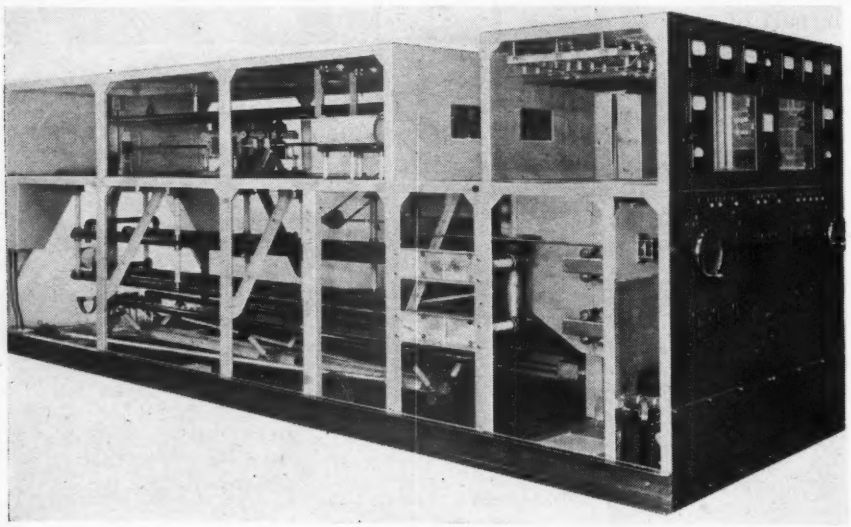


Fig. 2—General view of the left side of the 200 kw OWI international broadcast transmitter power amplifier showing arrangement of the copper pipes feeding excitation to the filaments

The design of the station transmitters presented many problems because of the fully-modulated 200-kilowatt carrier power specified for the allocated frequency range of from 6 to 22 megacycles. Though many of the components, including the power supplies, rectifiers and modulators, are somewhat conventional in design, the final radio-frequency power amplifier stage is rather unorthodox in that it utilizes a grounded-grid, push-pull amplifier with tuned input and output circuits. (Fig. 1)

This circuit, which is sometimes referred to as an inverted amplifier, was selected because of the many advantages it offers in high power operation at these frequencies. With the use of power tubes capable of providing the required power output in the conventional bal-

*"OWI-CBS 200 Kw West Coast Transmitter," Robert N. De Hart, CBS, E I, April, 1945.

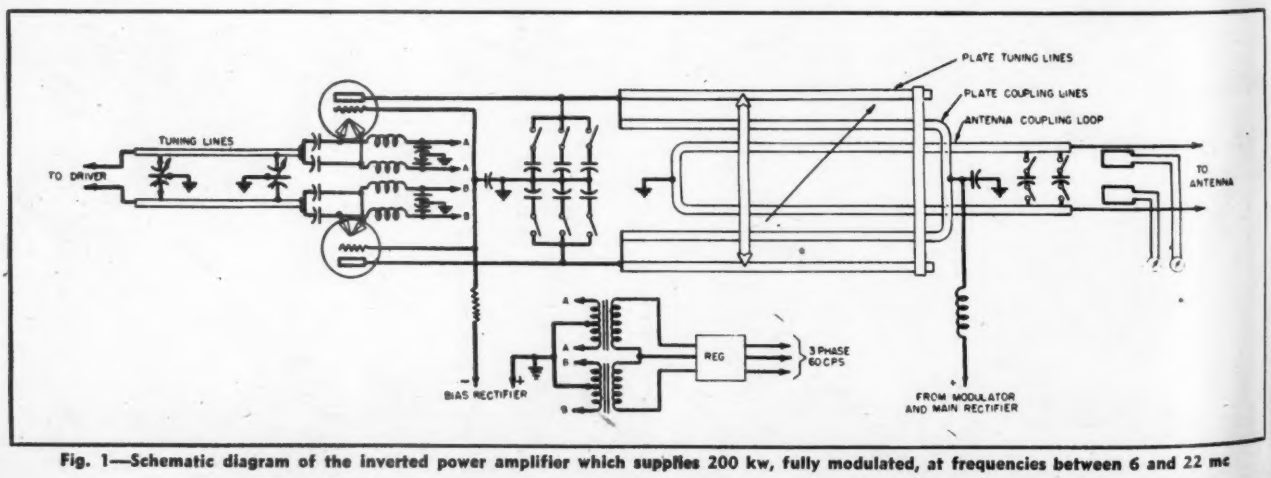


Fig. 1—Schematic diagram of the inverted power amplifier which supplies 200 kw, fully modulated, at frequencies between 6 and 22 mc

OF OWI 200 KW UNITS

anced amplifier and their unavoidably larger interelectrode capacitances, it becomes difficult to resonate the circuits to which the tubes are connected. Moreover, the grid-plate neutralizing capacitances would add to the tube capacitances and seriously limit the design of the output circuit inductance and considerably reduce the overall efficiency of the amplifier.

These problems are more easily solved by the inverted amplifier through the screening effect of the grounded grids and the reduction of output circuit capacitances, as compared with those of the equivalent balanced amplifier. Neutralizing condensers are entirely eliminated and it becomes practical to use very large tubes at relatively high radio frequencies.

In the inverted type of amplifier the excitation power is applied to the cathodes, instead of to the grids, which are held at ground potential. Therefore, the power developed in the amplifier plate circuit is in phase with the power developed in the driver, and as a result, in order to obtain full modulation in radio telephone operation, it is necessary to modulate the driver as well as the amplifier.

Since the driver is effectively in series with the amplifier plate by means of the cathode-to-plate electron stream, the power developed in the output tank circuit consists of the power delivered by the driver (except for any portion lost in the amplifier grid circuit) plus the power developed by the amplifier. Greater excitation energy is required, but there is no sacrifice in overall efficiency.

Driving power for the 200 kilowatt amplifier is provided by a 50 kilowatt transmitter which was supplied from OWI stock. Since this unit was originally designed for operation into an antenna, provision was made for adjusting the input circuit impedance of the larger amplifier to the normal load impedance for the 50 kilowatt unit, so that the output coupling facilities of the latter could be employed without alteration. As the driver must be modulated simultaneously and to the same degree as the power amplifier, its plate supply is obtained from the same modulated source as for the 200 kilowatt power amplifier.

The power amplifier is mounted in a frame 22½ ft. long, 6 ft. wide, and 6½ ft. high. Fig. 3 shows a view of the front panel from which all circuit adjustments are made with the exception of plate tank circuit capacitor switching. The two controls for the variable capacitors in the input circuit are operated directly by means of handwheels, all other controls be-

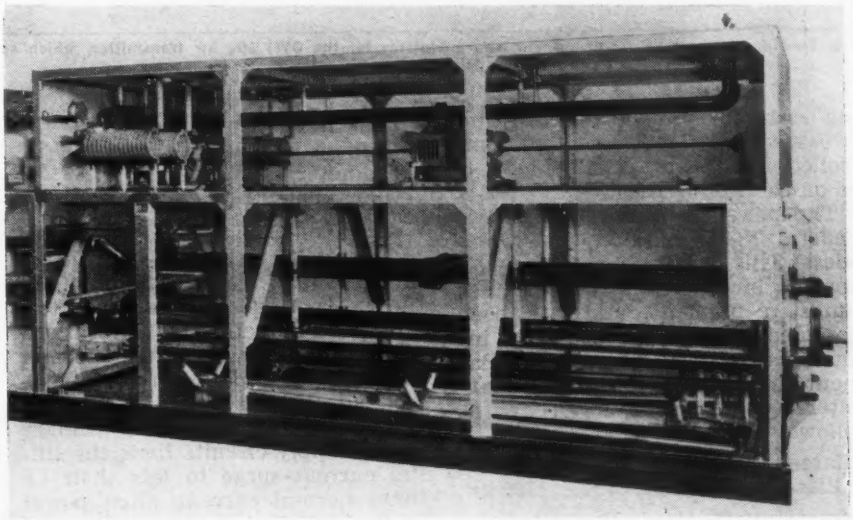
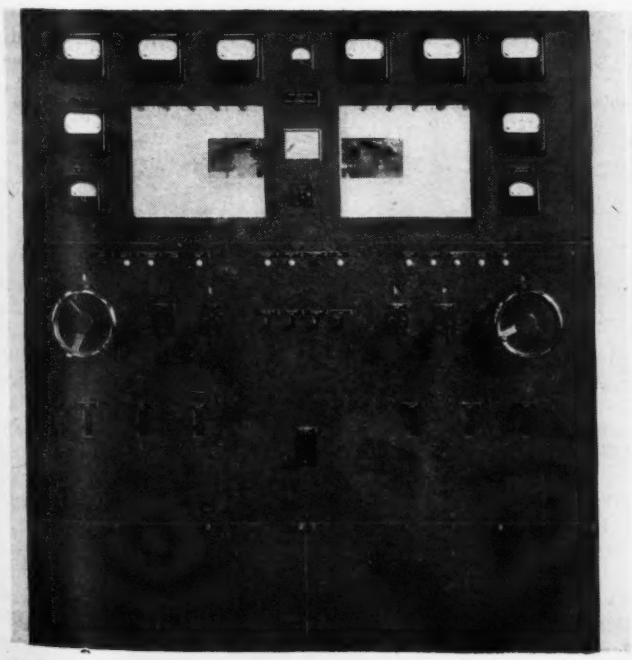
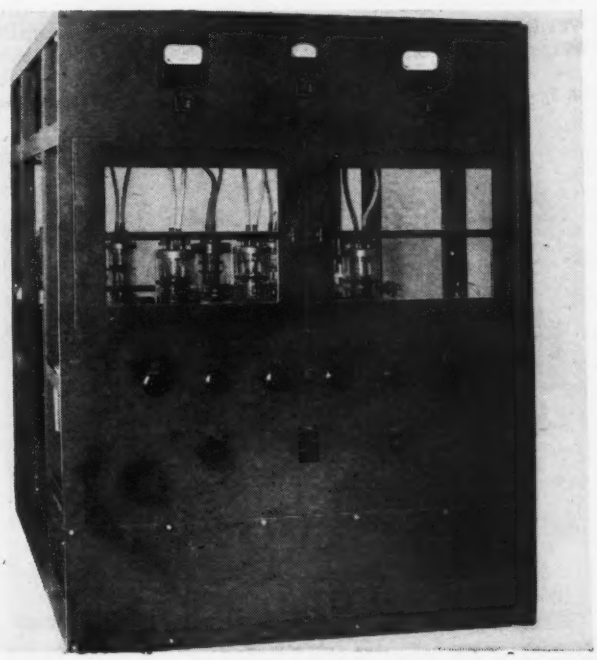


Fig. 4—(Above) Right side of rear section of power amplifier. Filament chokes, input circuit transmission lines and tuning capacitors are in upper section; plate inductance and antenna pick-up loop in lower section. Fig. 3—(Left) Front view. Fig. 6—The 150 kw modulator





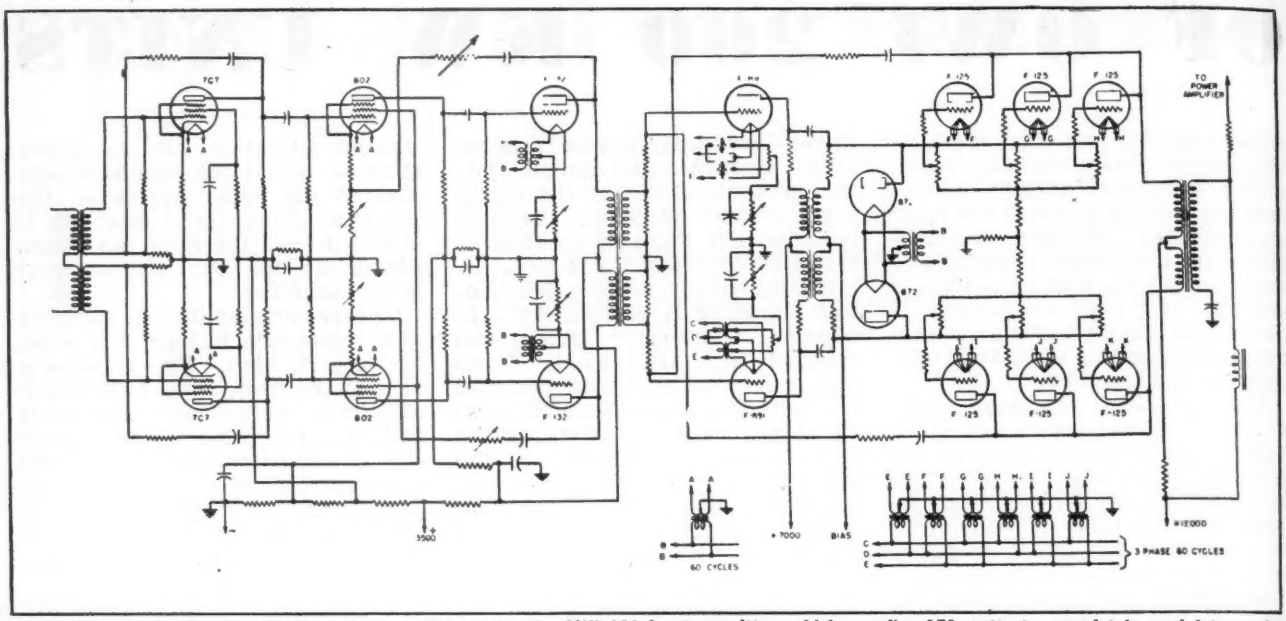


Fig. 5—Simplified schematic diagram of the modulator for the OWI 200 kw transmitter, which supplies 150 watts to completely modulate carrier

ing operated by means of reversible two-speed motors, which are controlled, in turn, by switches mounted on the front panel.

The power amplifier utilizes two Federal F-135-A water-cooled triodes. This tube is a recent development incorporating a thoriated-tungsten filament, and has been designed to minimize grid-lead inductance as well as plate-to-filament capacitance. Principal characteristics of the F-135-A are as follows:

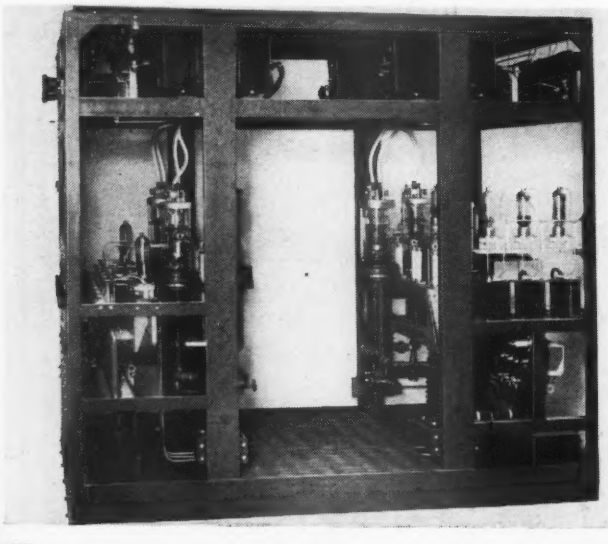
Filament: Single phase
Plate Dissipation .....100 kw.
Direct Interelectrode Capacitances:
Grid-to-Plate ..... 125 mmf.
Grid-to-Filament ..... 125 mmf.
Plate-to-Filament ..... 4 mmf.
Overall Dimensions:
Length ..... 30 in.
Diameter of Anode..... 6 in.
Diameter of Glass Envelope ..... 6½ in.

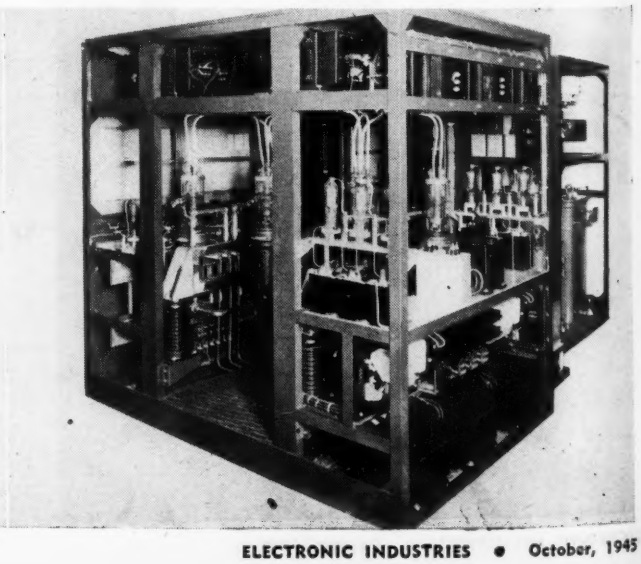
A pair of transformers, connected in open delta to the 230-volt, three-phase supply, feed the filaments of the F-135-A tubes. Motor-operated, air-cooled induction regulators control the voltage at the transformer primaries and permit remote-control adjustment of the filament voltage. Resistors in the primary power supply circuits limit the initial current-surge to less than 1.5 times normal current when power is first applied to the cold filaments.

Since the rf excitation is applied directly to the filaments in the inverted amplifier, it was necessary to design special rf chokes capable of carrying the 385 amperes of filament heating current. Sections of copper tubing, about 20 in. long and with an outside diameter of approximately eight inches, were spiral-cut on a lathe to form a very rigid coil of copper bus 1 in. wide and ½ in. thick. Because of the low impedance of the input circuit, the few hundred ohms reactance provided by these chokes is sufficient to prevent any appreciable power losses.

Excitation energy is fed to the power amplifier filaments from the transmission lines leading from the 50 kw driver by means of two parallel copper pipes 18 in. apart and about 12 ft. long. Two variable capacitors, controlled by the hand-wheels on the front panel, are used

Fig. 7—(Left) Right side view of the complete 150 kw modulator showing physical arrangement of various components. Fig. 8—(Right) Rear view





to tune the input circuit. One of these capacitors is fixed in position at the filament end, the other being mounted on a four-wheeled dolly and supporting contacts which permit connection to any point on the input circuit pipes mounted above. This entire assembly may be moved along the length of the pipes by a motor-driven stainless-steel belt, controlled by a switch on the front panel.

Parallel copper pipes are also used for the plate-circuit inductance, which consists of two parallel pairs, each approximately 18 ft. in length. The inductance of one of these pairs is varied by means of a carriage-mounted shorting-bar which can be moved to any position along the length of the pipes by a stainless-steel belt, driven by a reversible motor, controlled from the front panel. The inductance of the other pair remains fixed, and provides for coupling to the antenna pick-up loop. The ends of this loop are pivoted so that it may be raised or lowered by a motor-driven worm which runs through a bracket supporting the loop. Thus the antenna coupling may be adjusted by means of front panel switches which control the action of the motor-driven worm. The pipes forming the plate circuit inductance also serve to carry the cooling water to and from the tubes.

Plate circuit capacitance is provided by fixed 100 mmf vacuum capacitors, specially designed and manufactured by Federal, which are switched in and out of the output tank circuit as required. These capacitors incorporate a small filament which may be heated occasionally to assure a high degree of vacuum.

The position of the variable capacitor along the input line, the position of the plate tuning carriage, and that of the antenna pick-up loop, are indicated by counters on the front panel, coupled by means of selsyn motors to their respective driving mechanisms. These motor-driven tuning facilities permit adjustment of the power amplifier in less than five minutes to any frequency in the transmitters' range of 6 to 22 megacycles.

A special carrier cut-off device protects against damage due to flash-over in the radio frequency circuits and antenna system by causing a momentary interruption of the carrier if the average level rises or falls more than a few per cent from a predetermined value. Breakdown in any rf circuit thus will momentarily disable a low power stage, and if the ensuing interruption of excitation to higher power stages fails to clear up the fault, the cut-off apparatus will continue to re-cycle until the operator shuts down the equipment.

The audio frequency equipment is divided into a low power unit, an intermediate amplifier unit, and the modulator unit. Push-pull circuits are used throughout, satisfactory harmonic suppression and good stability being obtained with three separate negative feedback

(*Continued on page* 158)

Fig. 9—Front view and control panel arrangement of the audio amplifier for the transmitter

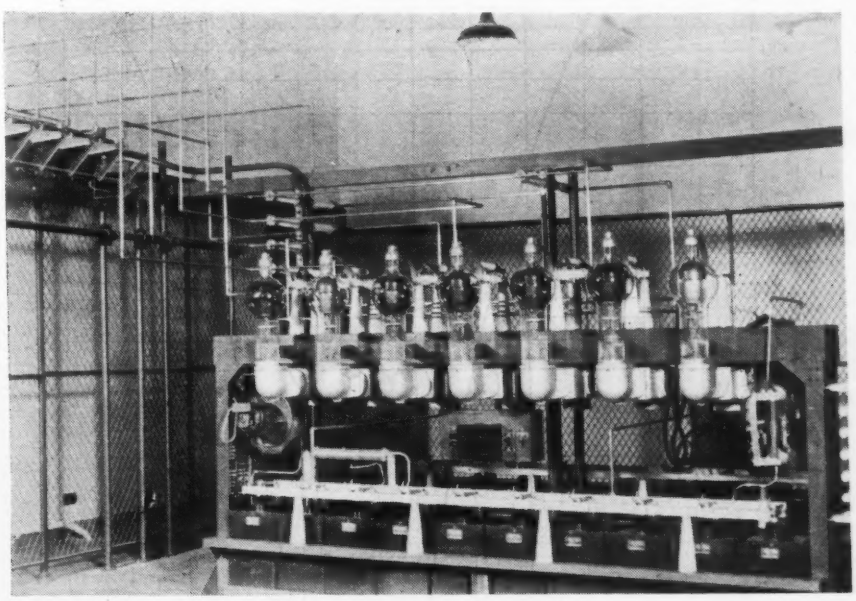


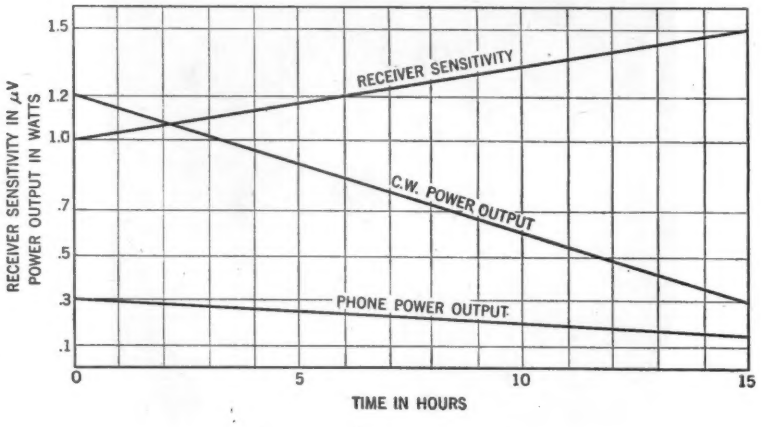
Fig. 10—View inside the rectifier rack capable of supplying 300 kw of power, showing one bank of seven Federal F-857A mercury-vapor rectifying tubes, one kept hot for emergency substitution

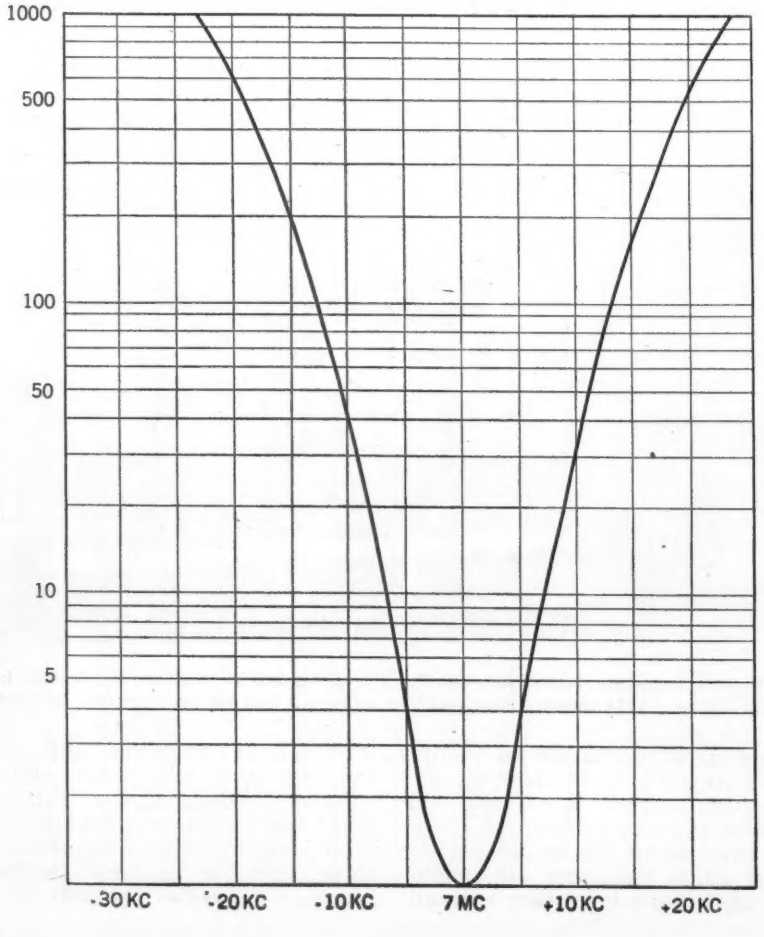
ENGINEERING BRITISH

Technical features of Americanized design for combined mobile transmitter-receiver developed for military liaison

● The very nature of modern warfare necessitates the use of large quantities of portable communication equipment. Of all such equipment probably the most important was a medium range battery-operated radio communication set, light and simple enough to be carried and operated by one man. This was one of hundreds of items which American industry produced and supplied to our British ally.

In 1940 the British had designed and made such a set known as Wireless Set No. 18 or, for short, B18. So great was the pressure on the electronic industry in Britain at that time that insufficient quantities were forthcoming, and it was decided to supplement British production by having a similar set manufactured here. Several of these B18 sets were sent to this country to serve as a background for developing the American counterpart.





Frequency varies

The requirement for the new set was that it should conform both in physical dimensions and weight to the B18 and that its electrical performance should be the best obtainable, but in any case not worse than the B18.

Extensive tests and measurements, part of which were made by the Emerson Radio and Phonograph Corp. Laboratories, served as the nucleus for the final specification of the British Wireless Set No. 48 or, for short, B48, now in use by the British Armies.

The B48 set consists of a transmitter and receiver complete with all accessories required for both phone or cw operation. It is intended primarily for short-range communication between infantry units. It may be used as a fixed ground station working in the open, or from cover or as a man-carried pack set for working on the move. It also works from either stationary or moving vehicles. For mobile operation the set is fed from a compact self-contained "battle battery." For fixed station work, it can be operated from its heavy duty battery pack or from a special light-weight, hand-cranked generator, which was developed by Emerson. This generator complete,

Fig. 3—(Upper) Graph of receiver sensitivity, and power output of transmitter when battery operated

Fig. 4—Chart of the overall selectivity of receiver

B48 WALKIE TALKIES

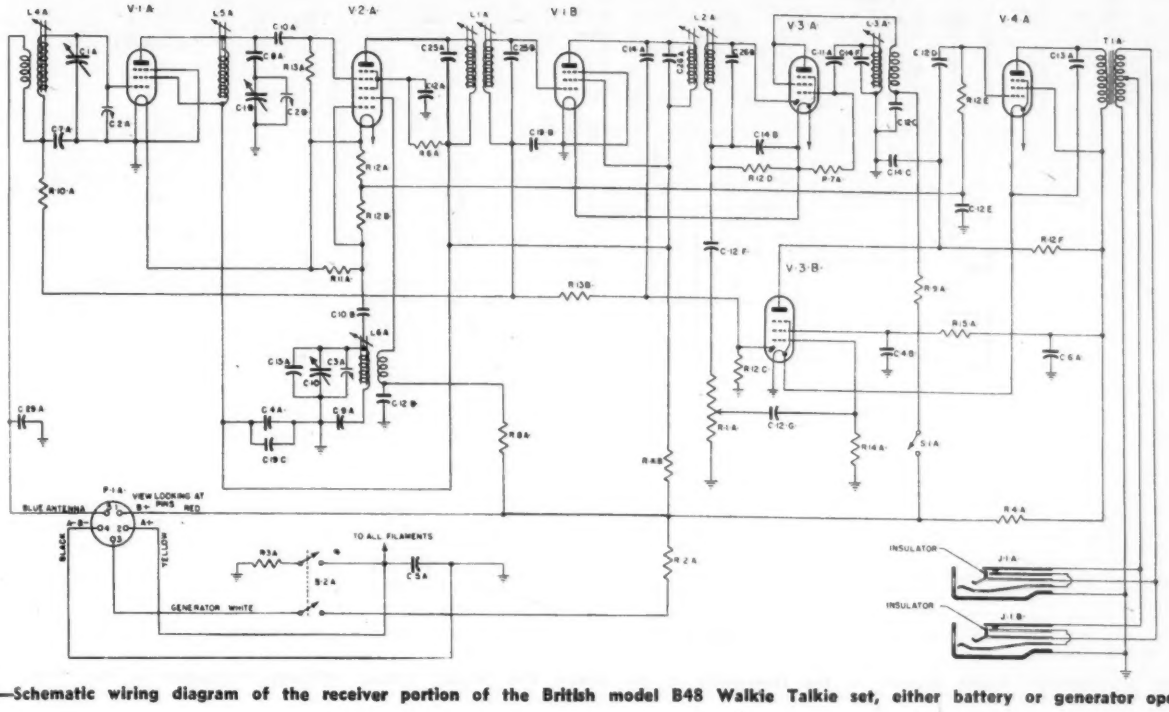


Fig. 2—Schematic wiring diagram of the receiver portion of the British model B48 Walkie Talkie set, either battery or generator operated

including legs, seat, filter enclosed in the generator housing, and voltage regulator weighs approximately 19 lb.

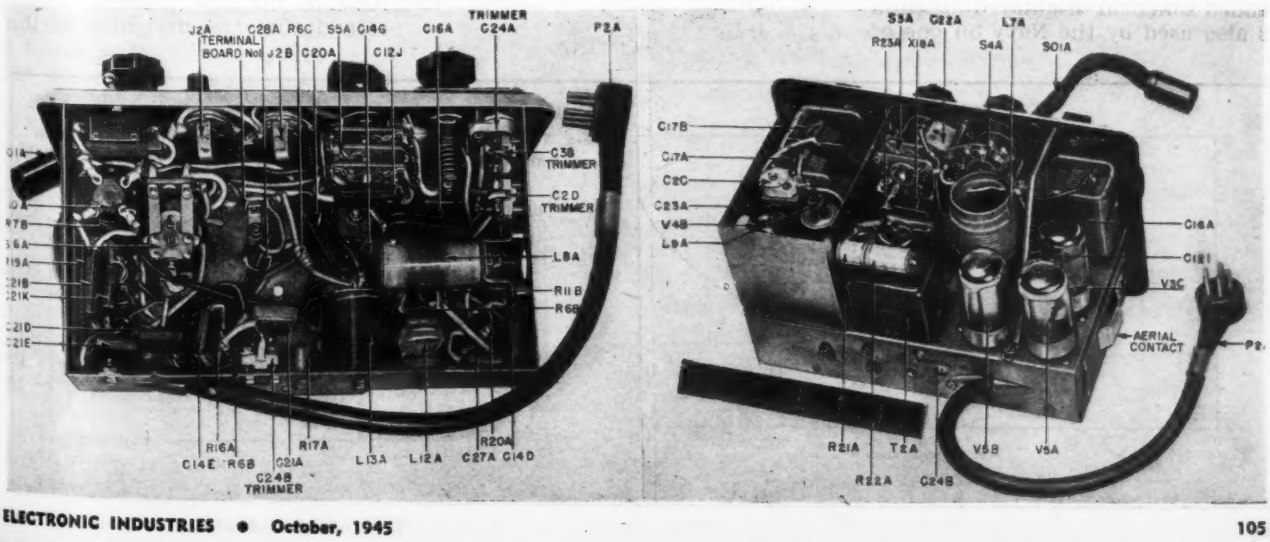
Antenna equipment

The transmitter-receiver, sectional rod antenna and battle battery pack are all contained in one case, fitted with straps so it can be carried on a man's back. When used with batteries, the set may be operated by one man, and by two men when used with the hand generator.

Function	Tube Type	Ef	If	Eb	Ecz	Ec1	Ib	Ic2	Gm	Rp	u
RF Amp. & IF Amp. . .	1LN5	1.4	.050	120	60	0	.95	.18	650	2 Meg.	—
Converter.	1LA6	1.4	.050	90	45	0	.55	.6	250	.75 Meg.	—
Detector Audio Amp..	1LD5	1.4	.050	120	—	—2.0	2.6	—	945	17,800	17
Audio Amp. Master Osc.	1A5GT	1.4	.050	90	90	—4.5	4.0	.8	850	.3 Meg.	—
Modulator Crystal Osc.....	1LD5	1.4	.050	150	90	—4.5	3.0	.9	—	—	—
Power Amp.	1299	2.8	.110	150	150	—8.0	19.0	3.2	3000	—	—

Fig. 1—Line-up and characteristics of tubes used in the B48 transmitter and receiver

Top and bottom views of the receiver chassis showing location and arrangement of components



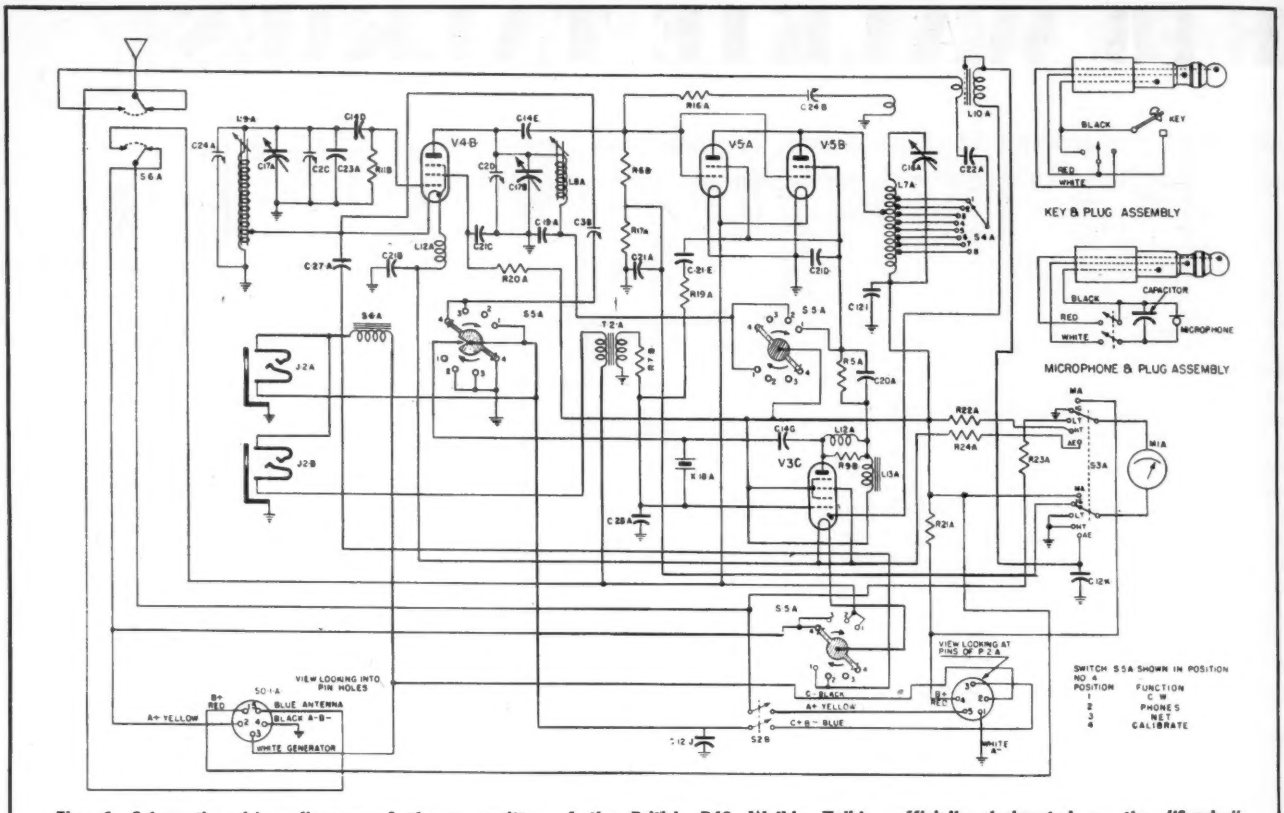


Fig. 6—Schematic wiring diagram of the transmitter of the British B48 Walkie Talkie, officially designated as the "Sender"

The sectional antenna is made up of eleven sections of painted steel tubing. For short-range work, as few as one or two sections can be used. For long-range work, all eleven sections may be used. When not in use, the sections are stowed in a rack on each side of the case.

The antenna is erected on the side of the case in a pivoted spring loaded socket which allows it to be vertical regardless of the operator's position. Provision is made for locking the antenna's position at any desired point in the arc of rotation by means of a screw and a captive knurled knob. This spring loaded Emerson originated antenna is also used by the Navy on one of their man-borne communication sets.

The British Royal Corps of Signals also requires that its equipment operate with a ground antenna—a 25-ft. length of wire. This antenna can be laid out on the ground or can be thrown over a bush or low tree to increase the range of the set. Exceptional improvements in signal-to-noise ratio are sometimes obtained with this arrangement. Typical service ranges are:

Antenna Type	Phone Range Miles	CW Range Miles
10 ft. rod	5	10
6 ft. rod	2-5	4-10
Ground Aerial	1-3	2-6

The front of the ribbed steel case in which the set is housed is closed by hinged metal flaps and a canvas hood. This hood provides protection against bad weather conditions. The battle battery is housed in the hinged bottom pan of the case. The transmitter slides into the lower section of the case proper, and the receiver into the upper, each being held in position by captive thumb screws. The chassis may be removed for inspection or maintenance. The microphone, head phones, key and 25-ft. wire are carried in a bag slung over the operator's shoulder.

One of the first problems which arose during the designing of the

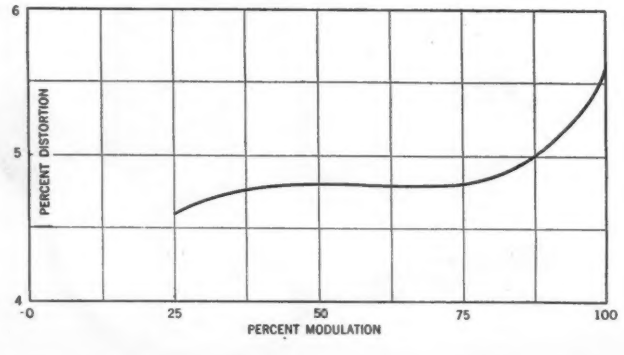
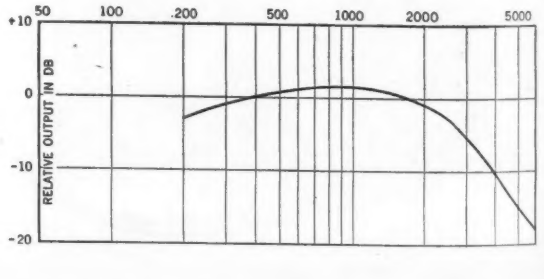


Fig. 7—(Left) Graph of percentage of distortion vs. modulation percentage of B48 transmitter. Fig. 5—Overall receiver fidelity



B48 was the selection of tubes equivalent to those used by the British. Because the B48 equipment must be operated from the same battery supply as the B18, this selection was not easy. After a careful survey of all the battery operated tubes, the complement shown in Figure 1 was selected.

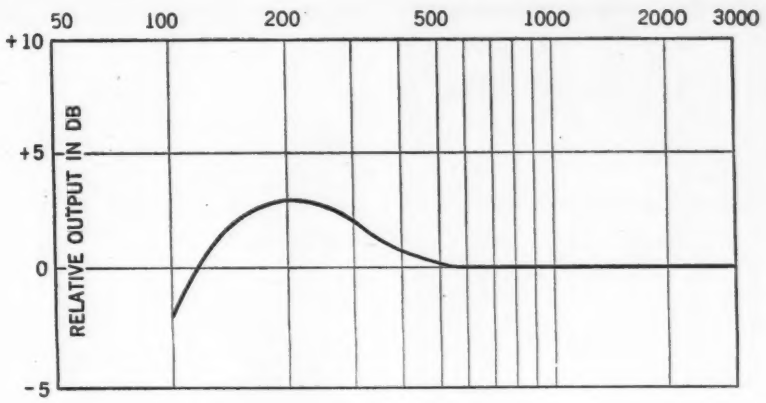
The B18 set used a common antenna coil for both the receiver input and transmitter power amplifier tank circuit. The coil and tuning condenser were mounted in the transmitter. While this method was economical, eliminating the need for a receiver antenna coil, it resulted in a serious reduction in performance. There was considerable loss of transmitter power output in the long lead which connected the receiver rf amplifier grid to the antenna coil. In certain circumstances when using the receiver, two tuning controls had to be manipulated, the main tuning control in the receiver panel, and the antenna tuning control on the transmitter panel. These disadvantages are eliminated in the B48.

Single tuning control receiver operation was achieved by using a separate receiver antenna coil in a conventional three-gang superheterodyne arrangement. Power losses were reduced by means of a newly-designed antenna switching relay located in the transmitter, which disconnected the lead to the receiver when the transmitter was operated.

Relay specs

The relay specifications presented many problems. It would have to use very little current to energize the field coil of the relay. It was necessary to be sure that the contacts would not be intermittent when the set was bounced or shaken. Since the rf output power of the transmitter is so limited, and the antenna is in the relay circuit, the relay had to be of a low loss, low capacity type. Special Mycalex insulation was worked out and found to be very satisfactory.

The B18 employed grid modulation which had one advantage in that no additional tubes were necessary. The microphone voltage was stepped up in an audio transformer and applied directly to the power amplifier grid. In the B48 screen grid modulation was employed, a form of modulation for which the 1299 tube is admirably suited. The modulator tube selected with a 1LD5 operating as an audio power amplifier with 150 volts on both screen and plate, and with the control grid biased at —3 volts. Laboratory tests showed that life of tube would be satisfactory as operated.



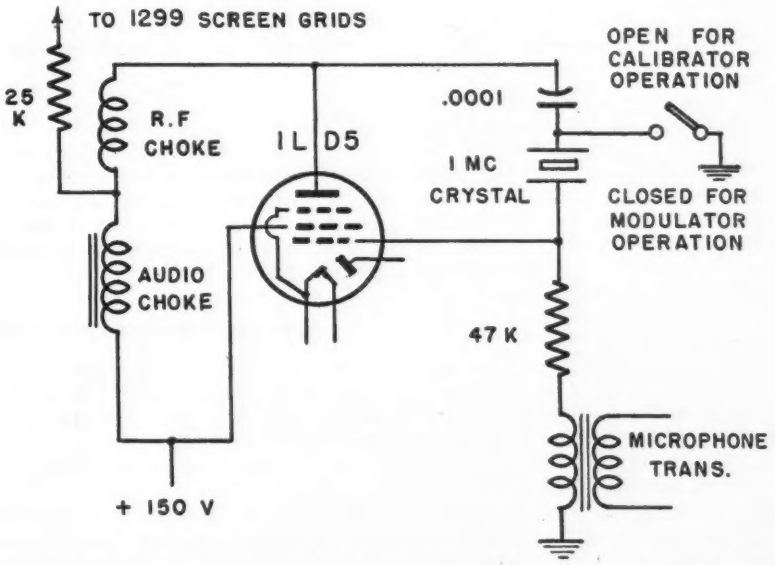
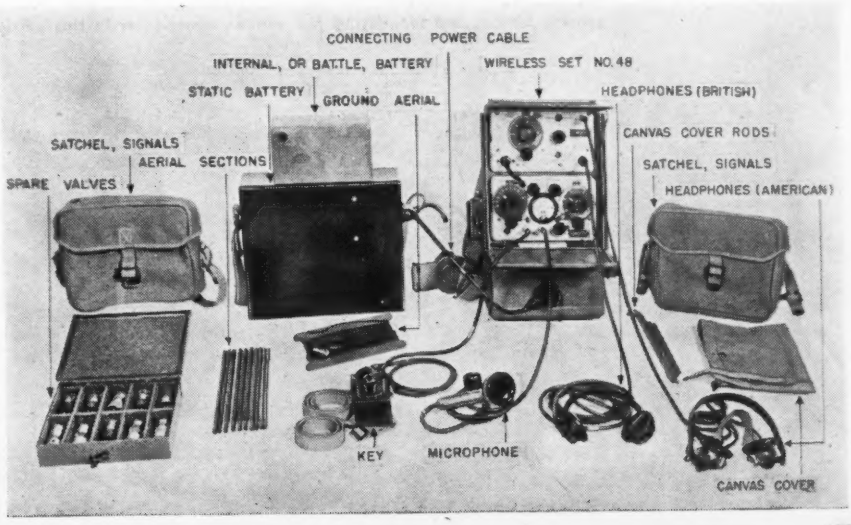
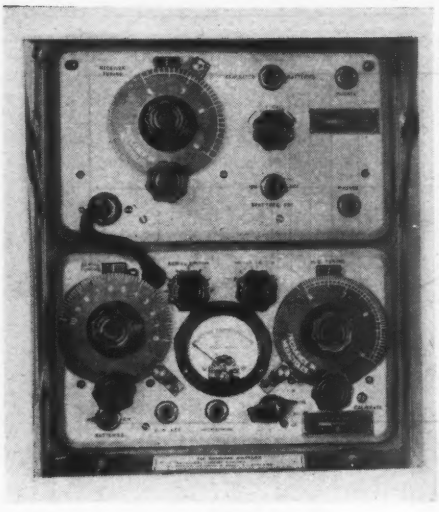


Fig. 8—(Above) Relative fidelity of the modulation system. Fig. 9—Simplified wiring diagram of the crystal controlled calibrator used in checking frequency of the transmitter

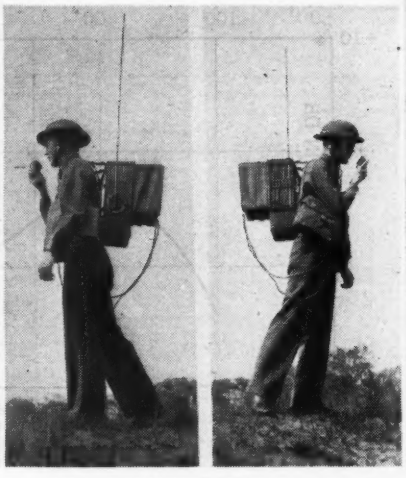
Using negative feedback, almost 0.1 watt of audio power was obtained. This is more than enough to modulate the transmitter 100 per cent. No increase in filament current was necessary because the

Here are shown all the various components in the B48 transmitter-receiver, as supplied to the British Army for operation on batteries. Equipment may also be hand-generator operated

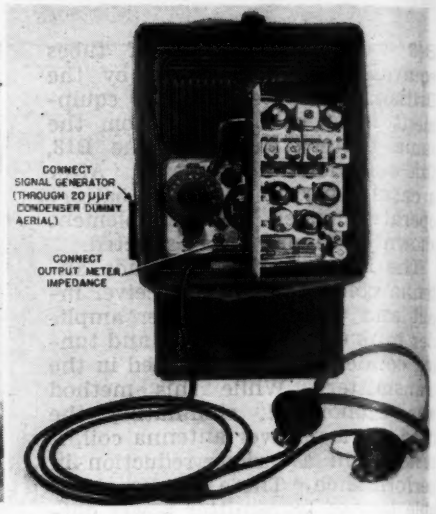




View of the control panel of the B48 receiver-transmitter radio



The equipment from both sides showing battery pack and antenna mounting



Top view of receiver unit as arranged for alignment procedure

1LD5 filament was merely substituted for the series resistor required for the 1.5-volt master oscillator filament operating from the 3-volt filament supply. The 3 ma of B current needed for the modulator was more than made up for by the reduction in total current resulting from the increased efficiency of the rf power amplifier.

The selection of the 1LD5 as modulator was dictated for reasons other than its power output, for if this were the only requirement the 1A5GT already used as master oscillator may have been much more suitable. The 1LD5 was selected because it was the only tube which delivered the necessary power output, and also contained a diode. The diode was needed for the antenna current indicator. A feature of the B18 set which permitted the operator to select the best tap on the power amplifier tank coil, for maximum power transfer into the antenna, was a dry disc rectifier connected to the transmitter output in series with a microammeter. In the B48 the diode is connected to a special transformer to the transmitter output in series with a microammeter. It was necessary to use a diode because American manufacturers of dry disk rectifiers would not furnish a disk rectifier to operate at radio frequency.

Superheterodyne receiver

The receiver is a superheterodyne tuning the range of 6 to 9 megacycles (Fig. 2). A stage of trf amplification insures good image rejection and high sensitivity with low noise. This is followed by a conventional pentagrid converter. The oscillator section is temperature stabilized by a small negative coefficient ceramic condenser. A single high gain stage of 455 kc if amplification is used. The two double tuned if transformers provide sufficient selectivity easily to meet the specifications.

A conventional diode, second detector is used. A 454 kc oscillator for cw reception is also provided. Since the cw oscillator tube is contained in the same tube envelope as the diode second detector, no external injection is required. Opening or closing a switch in series with the cw oscillator plate supply gives phone or cw operation as desired.

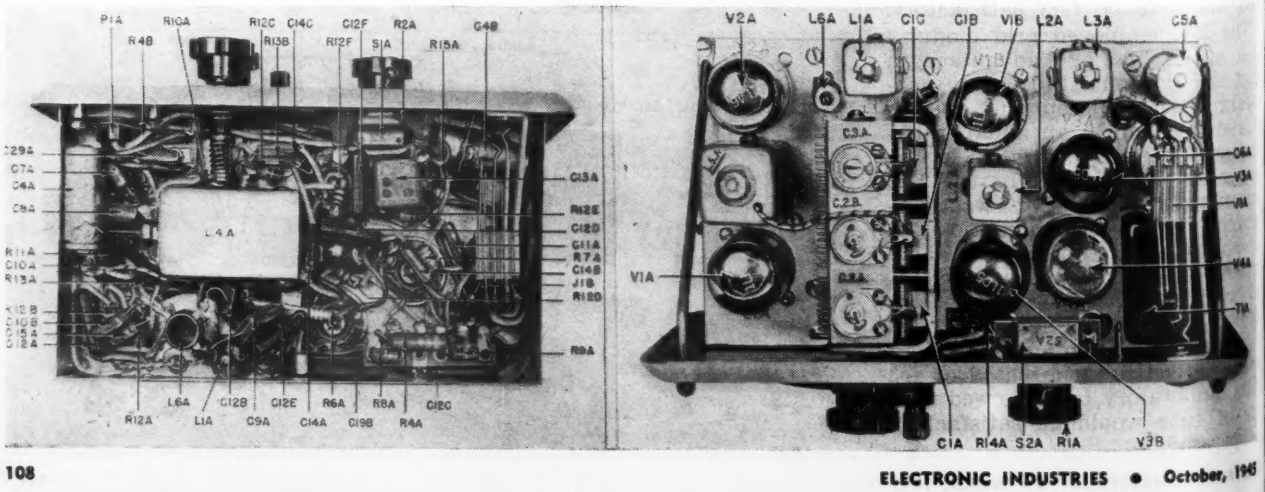
AVC voltage is developed from a separate diode coupled to the primary side of the second if transformer. This gives much better AVC than obtained from the secondary because the AVC action takes control over a broader band and is of greater intensity.

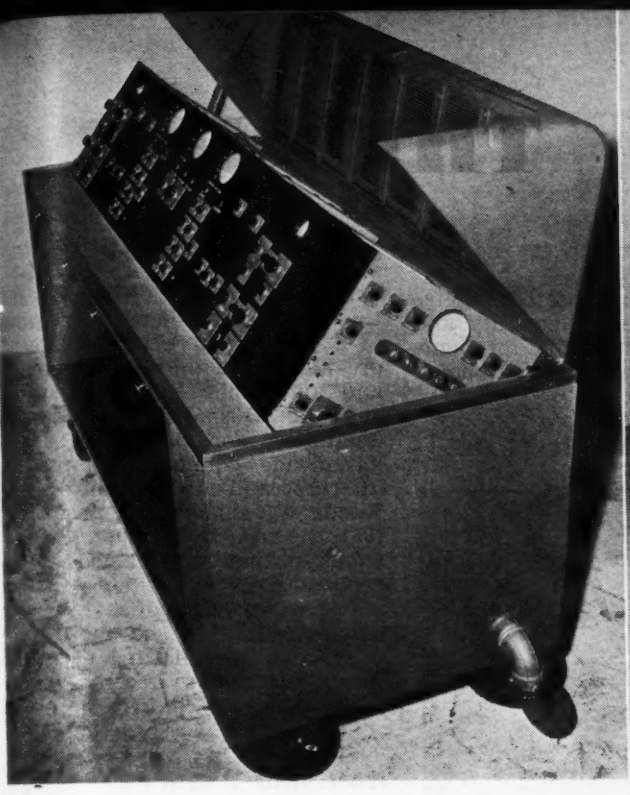
Two stages of audio amplification are used, to insure adequate audio volume, even at low percentages of modulation. Two output impedances are provided for either the high impedance American 'phones, or the low impedance British type. Automatic impedance selection is accomplished in the phone jack by taking advantage of the difference in phone plug lengths used with American and British phones.

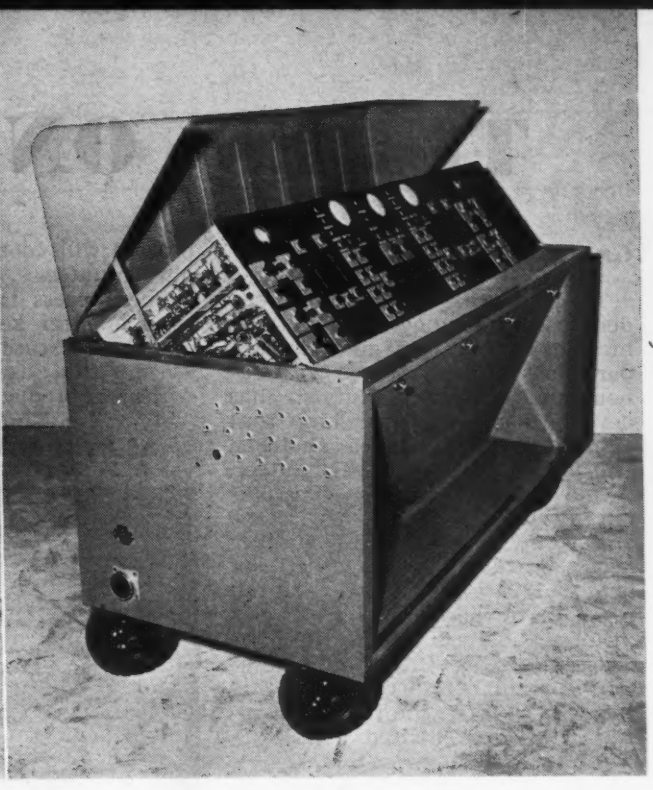
A group of measurements made

(*Continued on page* 130)

Top and bottom views of the transmitter chassis of the B48 Walkie-Talkie showing the general lay-out and identifying the various components in this portion of the equipment



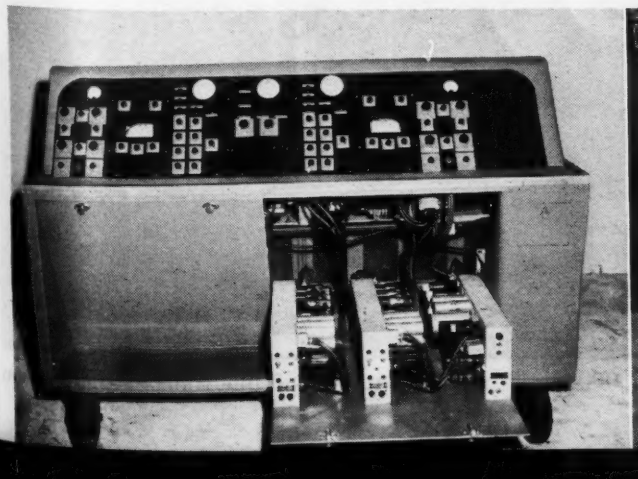


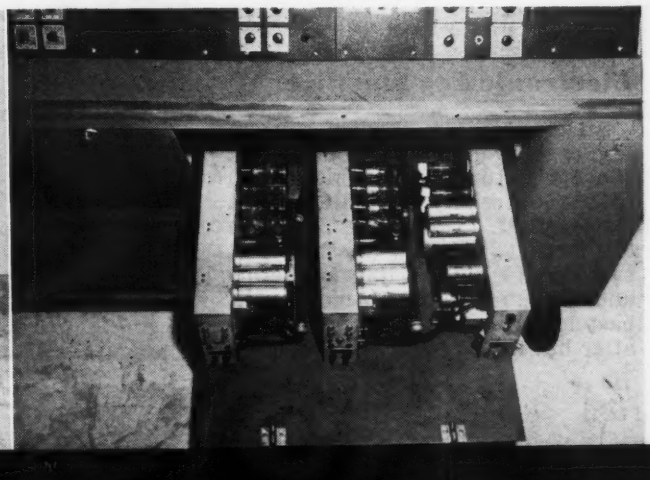


Mobile TELE Control

Something new in the realm of portable television control and monitoring equipment is Klaus Landsburg's "Telemobile." Landsburg is director of Paramount's television station W6XYZ, Hollywood, California.

The Telemobile combines all the control equipment necessary to operate two cameras, including synchronizing pulse generator, sweep signal generator, and monitoring units.





TUBES ON THE JOB

Grain Size Grading

To grade speedily metallic powders used by numerous industries in making pressed and molded parts Dr. P. F. Kalischer, Westinghouse research metallurgist, has developed a sorting machine that employs a glass tube, a photocell and light bulb and a milliammeter.

One gram of the specimen is mixed with 1/10th litre of acetone and a wetting agent. This mixture in a glass tube is mounted between photocell and light source. As the particles settle, more light passes through the glass tube to the photocell. By reading the milliammeter at regular intervals a plot is obtained showing the rate of clearing. This is compared with calibrations from known sizes.

Navy Electronic Applications Multiply

As an index of the growth in importance of electronic applications in our fleet, an interesting comparison recently came to light of the personnel engaged in planning the design, procurement, production, distribution, installation and maintenance of electronic equipment in the current war and in World War I.

At the time of the World War I armistice, the total staff of the then Radio Division which was established in 1910 numbered 75 officers and 25 civilians. As of April 1, 1945, the staff of the Electronics Division now under the direction of Captain J. B. Dow USN, has grown to 1160, composed of 459 officers, 487 civiilans and 214 Waves. Just prior to December 7, 1941, the total division personnel number was 107. In other words, the present personnel is sixteen times as large as the World War I group, and over eleven times as large as the personnel in the period just before our entry into the war in 1941.

Electronic Egg Sterilizer

An electronic method of sterilizing eggs is under development at the Agriculture Experiment station of the University of California at Davis, Calif. University scientists claim that the new method will successfully kill all interior germs and foreign egg growth along with bacteria growth on the egg shell after but ten seconds exposure. The process will cook the egg hard in nine minutees.

The process is expected to give eggs a better keeping quality and a higher texture quality for home use in that a stronger albumen coating is produced.

SUPER RADAR TUBE

It was a special radar tube, like this, designed and produced by Westinghouse, that was used in the radar set at Pearl Harbor which gave warning of the approach of the Japs in December of '41

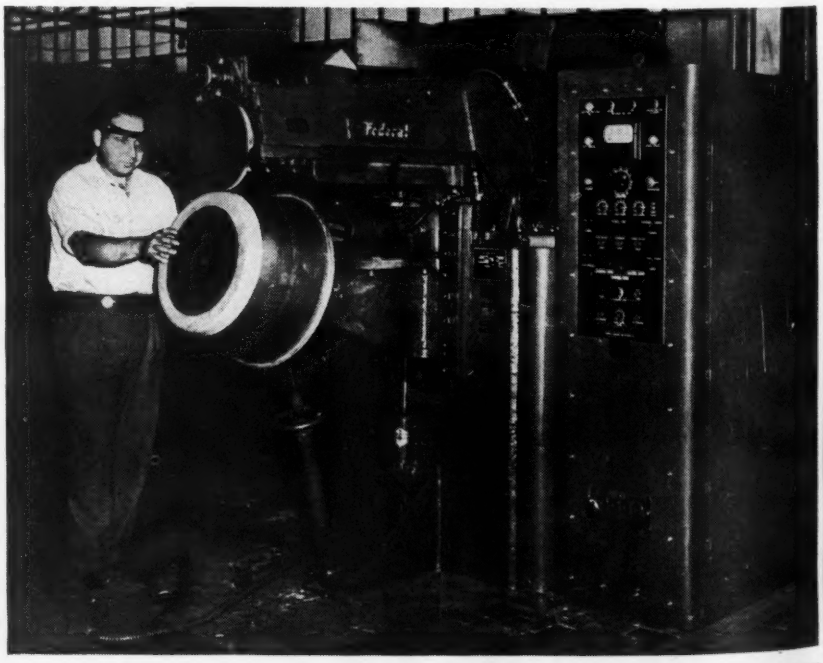
Speeds as high as 300 welds a second on .32 in. aluminum sheet are being made in production on this new type roll welding equipment

Electronic Output

Within a space of three years the electronic industry has grown to a point where it now exceeds pre-war production of automobiles and automobile equipment, points out the Business and Industry Committee for Bretton Woods, a nationwide committee formed to interpret and advance the Bretton Woods Agreements. From 1939 to 1941, the report continues, the electronic output was valued at approximately $300 million. By 1942, a volume of $1.5 billion had been reached, only to be more than doubled in the following years. The output just before recent military cut-backs was more than $4.6 billion.

Roll Spot Welder

Speeds as high as 300 welds per minute on .32 in. aluminum sheets are being obtained at the New Kensington plant of Aluminum Co. of America on this Federal welder. The Westinghouse electronic controls charge as many as 84-120 mfd capacitors (10080 mfd) from 1500 to 3000 volts with a peak demand of 100 kva on a three phase system. Each time this charge is "dumped" into the welder transformer, a weld is formed. The electronic controls for the capacitor discharge system assure the right amount of current for consistent welding results whether .032 in. sheet or .187 in. sheet is being put through the welder.



No Bubble—No Trouble!

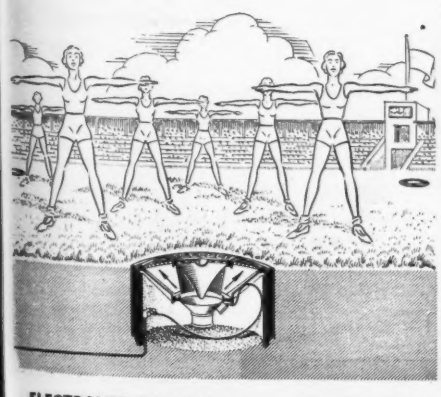
Marion Electrical Instrument Co., Manchester, N. H., has developed a new production vacuum checking apparatus — used to ascertain the perfect sealing of glass-to-metal 2½ and 3½ in. hermetically sealed indicating instruments. After the instruments have been sealed they are submerged in glass jars which are partially filled with alcohol. A vacuum of 25 in. is drawn and checkers watch for air bubbles which would indicate imperfect sealing. Spot checks for a period of four hours are made in a 29 in. vacuum.

Detectors Into Friskers

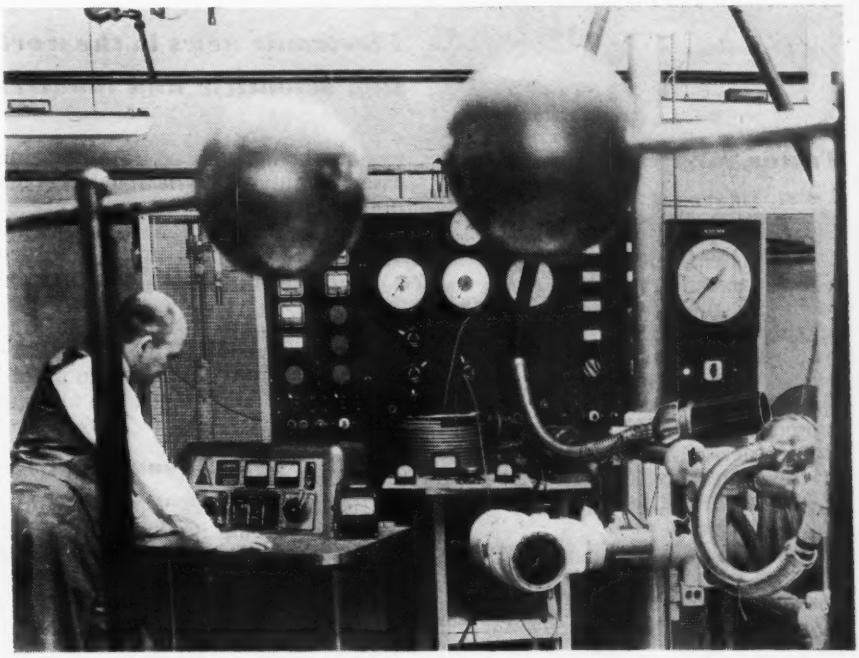
Returning GI Joes insist on bringing back in their luggage amazing relics in the form of live grenades and bombs, pistols and swords. As an aid to detection of such metal contraband before embarkation, all GI packs are now gone over with electronic "friskers," readapted from the electronic mine-locaters which played such a part at the front. And the mine locaters themselves were originally adapted from friskers used by FBI and police departments.

Underground Speakers

To obtain better sound distribution in large areas such as a stadium, loud speakers are being installed in concrete sub-surface mountings by German engineers. Advantages claimed by this scheme are infinite baffle area and more uniform sound distribution as well as lower costs than other types of installation.



HIGH VOLTAGE SPHERES OF INFLUENCE



This "sphere-gap view" shows a part of the new pilot-lab test panel in the Mount Vernon plant of North American Philips Co., where medical and industrial X-ray units are put through their paces. The sphere gap serves as a means of gaging the extremely high voltages used in part of the test routine

WIRED MUSIC INVADES THE GROCETERIA

Mrs. Joe Shopper walks into a food market, undecided whether to buy a can of salmon or a can of spamola for Joe's dinner. A dulcet voice in the offing warbles "The Fisherman's Song" and winds up with a commercial extolling the vitamins and calories lurking in the gizzards of the denizens of the deep. So Mrs. Joe buys a can of salmon.

This and other economic possibilities are latent in the surge of telephoned music which is exciting the moguls of mechanical melody in these parts. The idea is to pipe musical entertainment, judiciously mixed with commercial plugs, into markets, department stores, factories and other places where potential customers are wont to gather. Entertainment service, accompanied by plugs, is furnished free of charge, with the advertising sponsors footing the bills, as in radio.

Survey is under way in the Los Angeles area to feel out local merchants and manufacturers. As an example, the surveyors point with pride to the results in the Oakland, Calif., district, where approximately 50 chow markets are wired for entertainment combined with economic suggestions to housewives who are wavering between pickles and salad dressing.

Riveters' rhapsody

Several mechanical music units have been set up in defense plants, where the workers are given injections of melody every couple of hours to avert factory fatigue. Swank dress shops in Beverly Hills have adopted tuneful suasion, via platters, to attune the buyer to a $250 symphony in blue or mauve. Doctors' offices are being probed with the idea of installing wired music to fortify the patient against the rigors of the medico's drill or bill. Home installations are impracticable at present and will be for some time to come, with the telephone company controlling the wires.

Top company at the moment in this field is Muzak, with others breaking in. World Broadcasting and Transcriptions, parent company for Decca, and several other outfits are reported contemplating commercial as well as entertainment accounts, via wire, reports the publication "Variety."

SURVEY of WIDE READING

Electronic news in the world's press. Review of engineering, scientific and industrial journals, here and abroad

Tester for Plastic Windows

J. McG. Sowerby and W. H. Walton (Journal of Scientific Instruments, London, April, 1945)

The instrument was designed for use in the factory or industrial test room for the "pass-reject" testing of the optical distortion of small, transparent, domed windows molded from thin plastic sheets. The optical system (see figure) is so designed that the small central light stop cemented to the upper surface of the collecting lens intercepts all the light when the rays are sharply focussed.

The insertion of a perfect plastic window causes no appreciable deflection of the light beam as the rays are everywhere nearly normal to the surface. Thus the focus of the light on the stop is not impaired. A faulty window, whether the fault consists of non-uniform thickness or slight scratching, deflects the rays and the light beam is no longer completely intercepted by the stop. The deflected or scattered light is collected by the collector lens and is brought to a focus on the cathode of the photocell. The amount of light reaching the photocell is therefore a measure of the optical distortion of the window; faults which merely reduce the visual brightness can not be detected.

Constructional details of the optical arrangement are given. Particular care must be taken to maintain correct alignment of all optical elements.

Trigger and amplifier

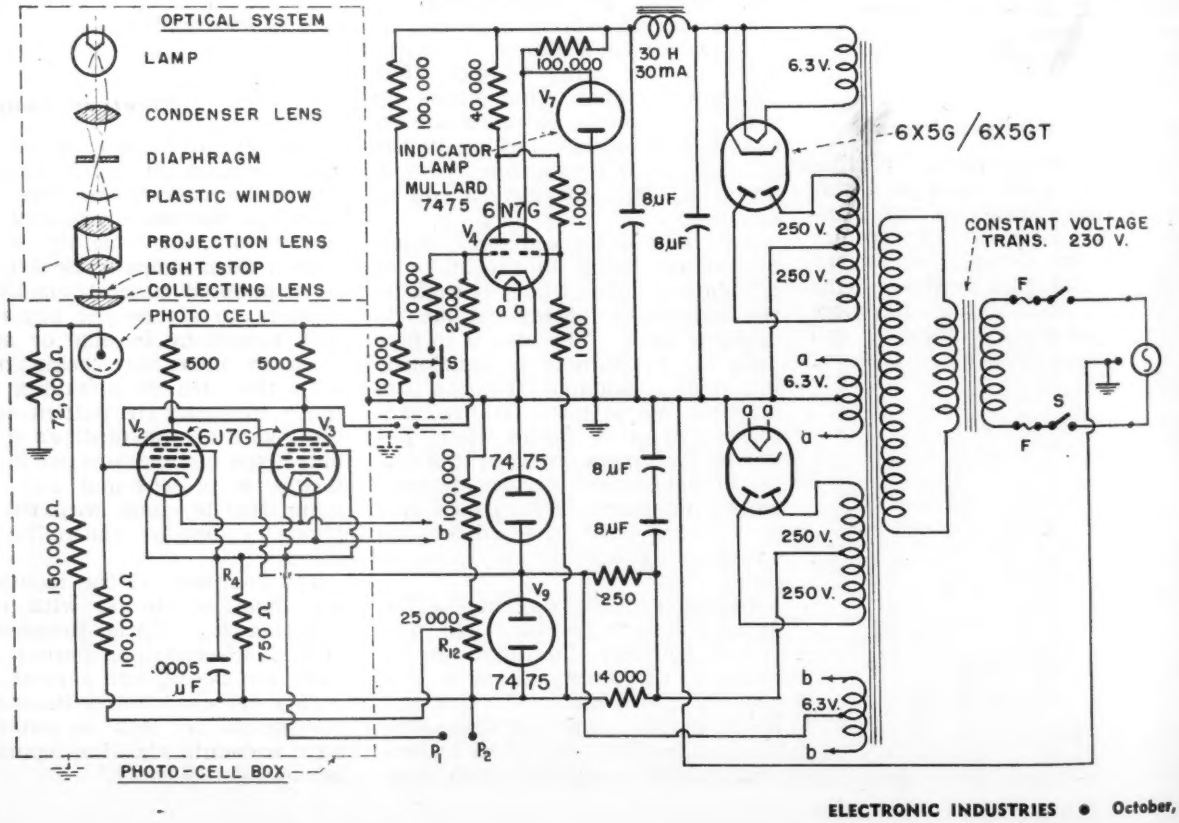
The two pentodes V_2 and V_3 form a trigger circuit having two stable states; they are controlled by the photocell current. Assume no photocell current and the slider of R_{12} at the potential of the negative voltage supply. Then the grid of V_3 is positive with respect to the grid of V_2 by the voltage drop across tube V_6 (about 100 volts) and this voltage appears across R_4 since the common cathode potential rises just above that of the more positive control grid. V_2 is therefore cut off and its control grid current is very low.

As the photcell is illuminated increasingly, the grid potential of V_2 approaches that of V_3, as soon as V_2 passes appreciable current V_3's screen voltage falls and V_2's rises. This is clearly a cumulative action so that V_3 cuts off and the current through R_4 is suddenly switched from V_3 to V_2 with consequent large voltage changes across the plate resistors. V_2 is left working approximately as a cathode follower so that a high grid leak is permissable and control is retained. When the illumination on the cell decreases and the potential of V_3's grid again approaches and falls below that the V_3, the trigger action is reversed.

The circuit is designed for comparatively low power input and is therefore especially suitable for direct operation from a photocell. The sensitivity can be adjusted by varying the slider of R_{12} which controls the photocell current required to operate the trigger.

When the trigger operates, the large voltage change at the plate of V_3 is amplified in the first sec-

Pass-reject tester for small plastic windows consisting of optical system, photocell, trigger circuit, amplifier and indicator lamp



tion of V_4 and applied to the grid of the second section of V_4 biasing it beyond cut-off. Previously this tube section was carrying current and the voltage across its cathode-plate space was considerably below the running voltage of the neon tube V_7 which was therefore extinguished. With the current through the second section of V_4 cut off, the voltage across V_7 is increased and its light indicates a failed window.

Spurious indications of bad windows due to operation of the trigger by the flanges of the windows while they are being placed in position on the instrument are prevented by the switch S. It grounds the grid of the first section of V_4, V_7 is lighted. Upon depression of switch S when the window has been correctly positioned, V_7 extinguishes if the window is acceptable and remains alight when it should be rejected.

Plug terminals P_1 and P_2 were taken out across R_4 so that on removal of V_3's heater supply, V_2 behaves as a linear current amplifier allowing the changes in photocell current to be indicated indirectly on a high resistance voltmeter applied across P_1 and P_2.

Electron Trajectories in a Plane Diode

Leon Brillouin (Electrical Communication, Vol. 22, No. 3)

The following theorem regarding electron trajectories is proved: In a plane diode with hot cathode and space charge operated under arbitrary voltage variation as a function of time, electron trajectories never cross each other provided electronic emission on the cathode is continuous and the current does not become negative. Conditions for negative current are also considered. This theorem was based on some of the equations derived in a previous article "Transit Time and Space-Charge in a Plane Diode" (Electrical Communication, Vol. 22, No. 2) by the same author.

AC Amplifier and Voltmeter

L. C. Roess (Review of Scientific Instruments, July, 1945)

It is intended to measure the output of a rapid-response thermocouple in an infra-red spectrograph the incident radiation being interrupted at frequencies between 1 and 5 cycles. The low frequency amplifier and voltmeter designed for this purpose and capable of detecting 5.10^{-10} volt is described. The amplifier is sharply tuned to the interruption frequency and is required to have a very low inherent noise level below the thermal noise of the thermocouple resistance.

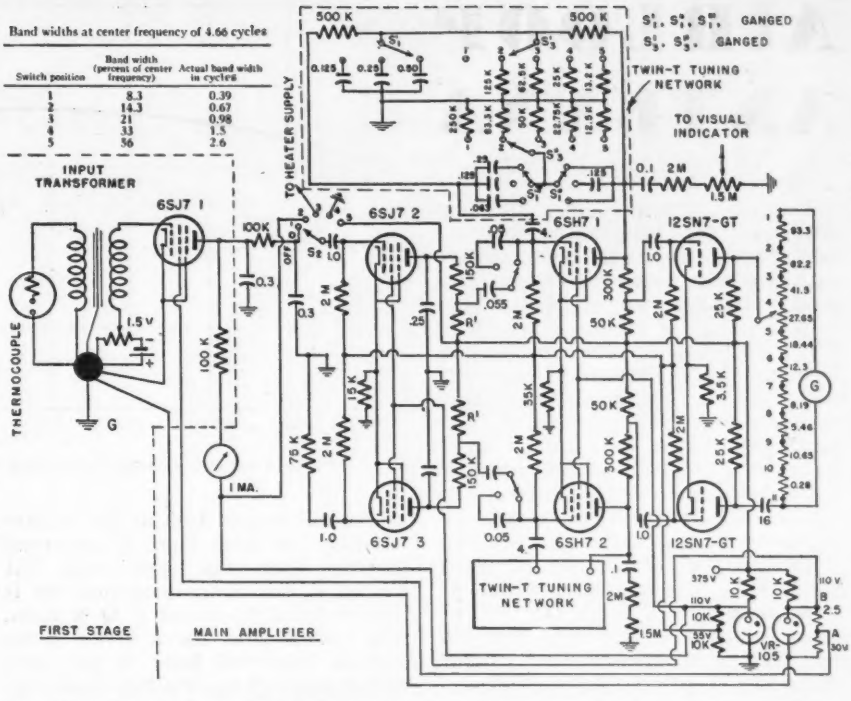


Fig. 1.—Circuit for measuring thermocouple output. Second push-pull stage incorporates two twin-T resistance-capacitance networks providing negative feedback to effect sharp tuning

Amplifier

Careful selection from a large number of tubes will yield a few having an inherent noise level of 5.10^{-8} volt referred to the grid; such a tube was used in the first amplifier stage. The thermal noise voltages of low resistance thermocouples are of the order of 2.10^{-10} to 2.10^{-9} volt which is much less than the noise of the first tube, indicating the use of a carefully designed input transformer if maximum sensitivity is to be attained.

In order to balance out any effects of fluctuations in the plate and screen supply potentials, the main amplifier following the first stage is connected in push-pull. This connection also permits the use of an unbypassed common cathode resistor in each stage introducing an appreciable amount of negative feedback. No loss of gain of the out-of-phase signal voltage results from its use, but a considerable loss of gain does occur for all voltages, such as plate supply voltage fluctuations, which reach both grids of a given stage in phase. The presence of the cathode resistor tends to equalize any unbalance in signal voltages at the grids of the individual tubes of each push-pull stage. This behavior makes it possible to feed the output of the first stage, which is single-ended, to the push-pull main amplifier without introducing a special phase inverter stage.

The two twin-T resistance-capacity networks connected to provide negative feedback from the plates to the grids of the second stage of the main amplifier, produce an effect equivalent to the introduction of sharply tuned resonant circuits. The amount of negative feedback increases rapidly from zero to a large value as the frequency is changed from the center or resonant frequency so that the grid to plate gain is reduced from about 350 at this frequency to about unity for frequencies somewhat larger or smaller. The sharpness of tuning depends upon the gain available between the points across which the feedback network is connected. Various experimental results for different positions of switch S_3 are given in the table at the top left-hand corner of figure 1.

By means of switch S_1 it is possible to tune the amplifier to 1.2,2.4, or 4.8 cycles. Amplification at higher frequencies, particularly at 60 cycles, is reduced by the resistance-capacitance networks shunted across the plate circuits of the first two amplifier stages.

The 12SN7-GT output tubes were chosen because they have the high mutual conductance necessary to couple the output of a voltage amplifier to a low impedance galvanometer. The entire swing of the

(*Continued on page* 166)

AIRLOOP ANTENNA

A new development in loop antennas for broadcast receiving sets combines high performance with low cost mass production and good physical appearance. This loop, a photo of which is shown in Fig. 1 is made of sheet copper on a punch press machine at rates far exceeding anything possible through wire-winding technic. The manufacturer* claims that thirty complete units can be made per minute, not only formed with terminals but attached to the back which forms a complete part of the radio receiver.

Sheet copper is fed into the press along with the material which is to be used as the back for the receiver or to hold the loop. The die on the press shears the copper sheet into a pattern which forms a continuous spiral from the outer edge around to the innermost end. The die having a "V" shape forces the copper ribbon which is sheared from the sheet into an inverted "V" cross-section as shown in Fig. 2.

At the same time the copper is sheared into this "V" cross-section it produces the necessary spacing between adjacent turns in the loop and acts to lock the loop to the backing material. In the locking of the sheared copper strip to the backing material, no additional cement or binding is necessary.

The loop illustrated in Fig. 1, has 34 turns and an inductance of 166 microhenries. The quality or Q of this loop over the broadcast band is given by the curve in Fig. 3.

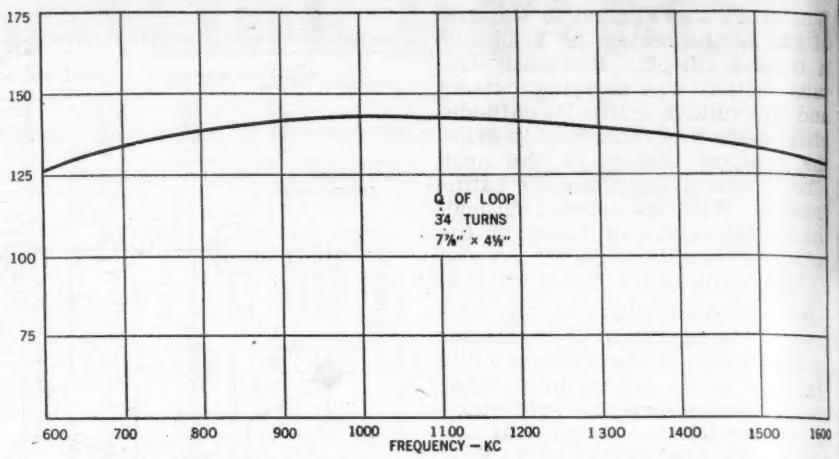


Fig. 3—Q characteristic for isolated loop in Fig. 1 over broadcast band range

The maximum area of the square "Airloop" is more than 27 per cent greater than old type oval flat wound loops. Since loop pick-up is proportional to turns x Q x area, this means that for a given space the air loop will have 27 per cent better pick-up than a flat oval loop, assuming the winding space for each loop to be the same. Effective areas are in the same ratio for the same width of winding.

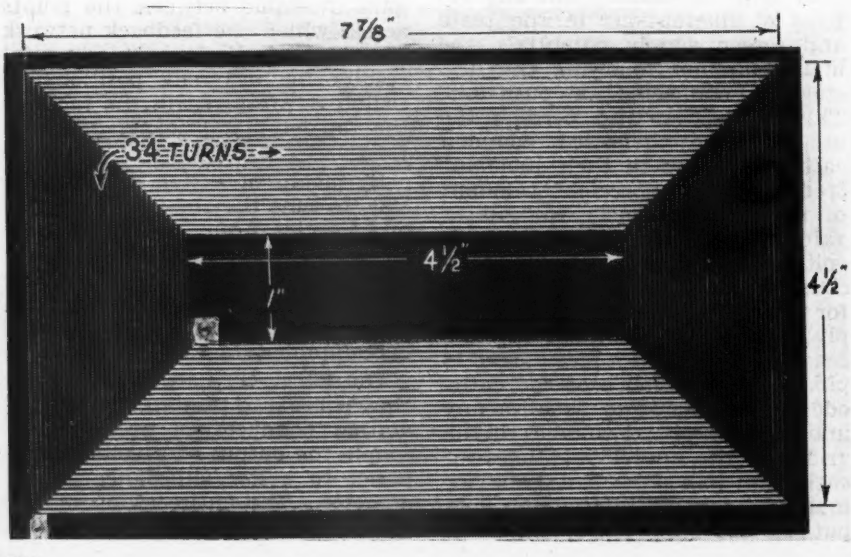
In the formation of the loop by a press method, the insulation between adjacent turns is primarily air. This is caused by the forcing of the copper sheet into the "V" formation which brings the adjacent surfaces of the turns up above the back sheet. Thus the backing sheet does not behave so much as a dielectric material as if it were between adjacent turns. The losses in the loop and the resulting Q are only slightly different for high grade insulating material than for common material such as press-boards, etc. Where the electric field is greater between adjacent turns, the only insulation is air, thus producing relatively high Q.

The large effective area of the conductor and the close spacing along with the minimum of insulation gives this loop its Q characteristics. Its mechanical rigidity makes is possible to have a greater permanence in the alignment of small broadcast sets using this type of antenna. The stiffness of the conductors and freedom from the use of cement means that a higher degree of stability in tracking in the tuned circuits is possible. Only 5 per cent reduction in Q after subjecting to 100 per cent humidity for 24 hours is claimed by the manufacturer.

For a Q of 75, the "Airloop" permits a saving in cabinet depth of ⅜ in. permitting lower cabinet cost, with no sacrifice in performance under that of a good quality solenoid loop. Conversely, for a given cabinet depth, better performance (Q) results from replacing the solenoid loop with the "Airloop." This is shown in Fig. 4.

*A. W. Franklin Company, New York City.

Fig. 1—Photograph of typical loop antenna, die formed from sheet copper, for small broadcast receivers



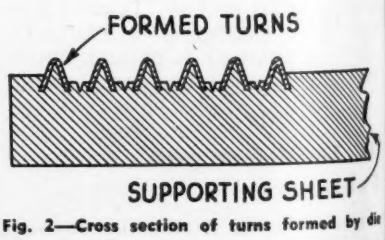
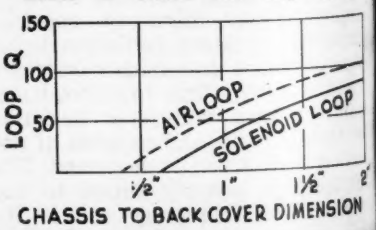


Fig. 2—Cross section of turns formed by die

Fig. 4—Comparison of Q for distances to chassis and loop types



NEW INSTANT-HEATING BEAM TETRODE

Ruggedized 2E25 FOR MOBILE OPERATION

Developed for Signal Corps portable, mobile, or emergency communications equipment, the 2E25 r.f. beam tetrode is easy on the battery. The thoriated tungsten filament permits simultaneous application of filament and plate potentials. Precious battery power is conserved during standby periods.

Completely shielded for r.f., the 2E25 requires no neutralization even at its maximum frequency of 100 megacycles. Other features are: low-loss octal base, plate connection to top cap, filament potential centered at 6.0 volts, and extremely rugged construction.

Consider the advantages of the 2E25 as an instant-heating replacement for the 6V6GT or 6L6G in older equipment, or for use in modern equipment such as the new Kaar mobile FM set illustrated. Remember, the versatility of the 2E25 beam tetrode simplifies the spares problem; this one type can power a whole transmitter—R.F. and A.F. Order your engineering samples today.

HYTRON 2E25

Instant-Heating 15-Watt R.F. Beam Tetrode

TENTATIVE ELECTRICAL DATA

Filament Potential	6.0 ± 5% ac or dc volts
Filament Current	0.80 amp.
Plate Potential	450 max. dc volts
Screen Potential	250 max. dc volts
Grid Potential	−125 max. dc volts
Plate Current	75 max. dc ma.
Plate Dissipation	15 max. watts
Screen Dissipation	4 max. watts
Grid Driving Power (Class C)	0.5 watt approx.
Power Output (Class C)	20 watts

AVERAGE DIRECT INTERELECTRODE CAPACITANCES

Grid to Plate (with external shielding)	0.18 max. mmfd
Input	8.5 mmfd
Output	6.0 mmfd

MECHANICAL DATA

Maximum Overall Length	4 3/16 inches
Maximum Diameter	1 1/16 inches
Bulb	T-11
Cap	Small metal
Base	7-pin med. short shell low-loss octal

The New 2E25 Supersedes and Replaces the HY65

New instant-heating mobile FM transmitter developed by Kaar Engineering Co. uses 7 Hytron 2E25 and 2 Hytron HY69 or HY1269.

WRITE TODAY to Dept. 10 for these: New Hytron transmitting and special purpose tube catalog; 21 x 17 inch sheet illustrating Step-by-Step Assembly of Typical Hytron Tube.

OLDEST MANUFACTURER SPECIALIZING IN RADIO RECEIVING TUBES

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS

NEWS OF THE INDUSTRY

Airline to Spend $10,000,000 for Radio

Indicating potential markets for airline communications and electronic equipment, United Airlines, Chicago, has let it be known that this organization plans to invest about $10,000,000 for voice and telegraph signalling apparatus and meteorological aids. Among other equipment, United plans on:

1. Airway traffic monitors, operating on the radar principle, which would enable airway and airport traffic control centers to maintain a visual watch on planes in flight.
2. Automatic position recorders giving pilots exact location information.
3. A radio-impulse device warning pilots of the presence of other planes in the immediate vicinity.
4. Automatic landing devices.
5. A radio means of making automatic written recordings, aboard planes in flight, of information transmitted from ground stations.

Aireon Adds Two

Aireon Mfg. Corp. has expanded still further in the radio electronic field through the purchase of two Chicago companies manufacturing speakers, microphones and other accessories. These are the Oxford-Tartak Co. and the Cinaudagraph Corp.

VHF for B & O

Marking one of the first railroad uses of very high frequency communication equipment, the Baltimore and Ohio railroad has placed an order with the radio division of the Bendix Aviation Corp. Most of the equipment will be installed in the railroad's New Castle (Pa.) yards.

Radio-Radar Museum

There ought to be a Federal national war museum of radio and radar, suggests the advertising committee of Radio Manufacturers Association. Chairman John S. Garceau of the advertising committee plans to present the matter at the next RMA board of directors meeting. Such a museum would include a complete display of radio and radar military equipment of historical character. Plan would be to include discarded and battle-scarred equipment used in historic battles.

Conventions and Meetings Ahead

Society of Motion Picture Engineers (J. Haber, Hotel Pennsylvania, New York City), 58th Semi-Annual Fall Conference, October 15, 16, 17, Hotel Pennsylvania, New York City.

The Instrument Society of America and the Carnegie Institute of Technology (Chairman Dr. B. R. Teare, Jr., Department of Electrical Engineering, Carnegie Institute of Technology, Pittsburgh 13, Pa.), Educational Conference on Instrumentation, October 16, 17, 18, Pittsburgh, Pa.

Electrochemical Society (Colin G. Fink, Columbia University, New York City), Electronics Division, October 17, Philadelphia.

Optical Society of America (A. C. Hardy, Massachusetts Institute of Technology), October 18, 19, 20, Hotel Pennsylvania, New York City.

Institute of Radio Engineers (330 West 42nd Street, New York City), Old Timers Night, November 8, Hotel Commodore, New York City.

Rochester Engineering Society (O. L. Angevine, Hotel Sheraton, Rochester, N. Y.), Rochester Fall Meeting, November 12-13.

Institute of Radio Engineers, Annual Winter Technical Meeting, Hotel Astor, New York, January 23-26.

Emerson Acquires Radio Speakers

Emerson Radio & Phonograph Corp., New York, has acquired Radio Speakers, Inc., Chicago. The company has for many years been one of the large producers of radio speakers. For the past four years, the company has been engaged in war production.

Heating Lab

A laboratory specializing on rf heating problems is soon to be opened for the benefit of west coast Westinghouse clients, at Los Angeles. The equipment includes a 20 kw generator for induction heating and a 5 kw generator for capacitive heating. Dr. R. A. Neilson is in charge.

DuMont Exec. Sees High Video Payroll

Television broadcasting stations will have a total national payroll of more than ten million dollars in the next three years, Paul E. Carlson, merchandising manager of Allen B. DuMont Laboratories Inc., told the graduating class of War Industries Training Program at commencement exercises held in New York City recently.

His prediction was based on existing payroll figures taken from presently operating stations, and multiplied by the number of applications for new video stations now being processed by FCC.

Three Video Applications

Three applications to set up commercial television stations at Pittsburgh and Lancaster, Pa., and Dallas, Texas, were filed with the Federal Communications Commission this month.

The Pittsburgh application was filed by Allen B. DuMont Laboratories Inc. of New York City. DuMont's application asks that the Pittsburgh station be allowed to operate on Channel No. 2. The New York firm has applications pending before FCC for stations at Boston and Washington, D. C.

The Dallas application was filed by the Times-Herald Publishing Co., Dallas, Texas, and asks for Channel No. 2. WGAL Inc., Lancaster, Pa., asked for television Channel No. 4 in Lancaster.

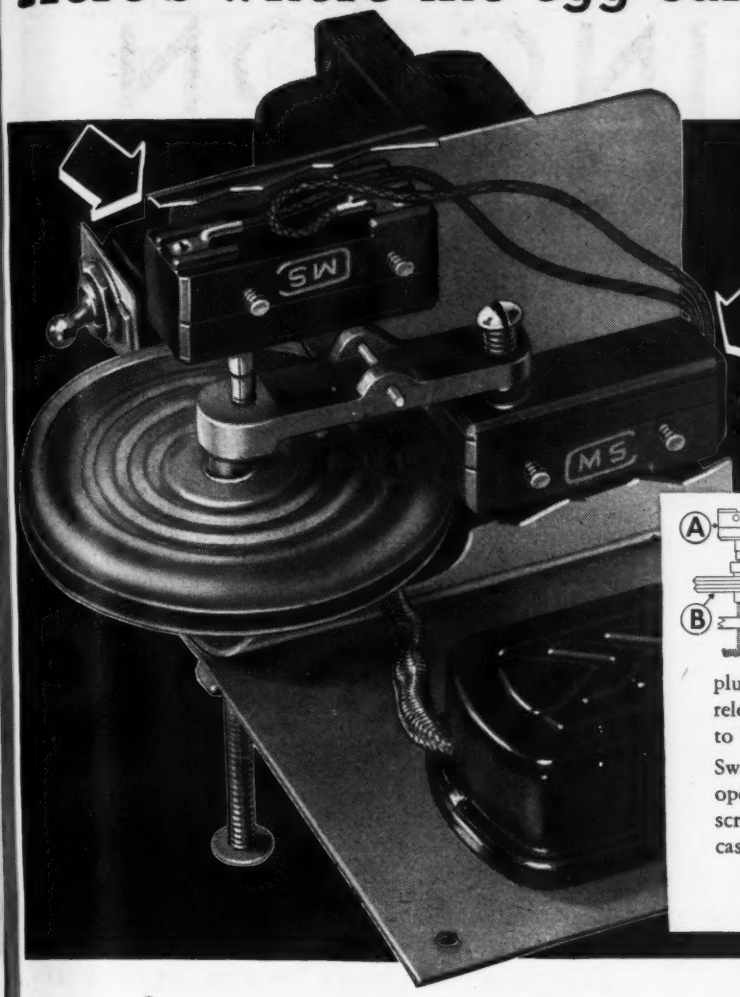
Echophone Receivers

The Echophone division of the Hallicrafters Co., Chicago, is going into the home receiver market with a line of console combination models, featuring AM, FM and short-wave reception. These will be built to receive on the new 88 to 106 megacycle FM band, and will carry the Echophone brand name.

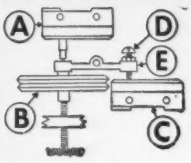
Universal's Nite Lite

Universal Microphone Co., Inglewood, Cal., has formed a new division for the manufacture of a tiny neon night light. The lamp, of 1/25th watt capacity, is of the plug-in type, plastic encased in an attractive transparent housing and may be used on either ac or dc. Trade name of the product is Robolite.

Here's where the egg came first



MICRO SWITCH
SNAP-ACTION
Helps bring the chick



Here is how it works

Switch "A" is held in an open position by the pressure of liquid filled bellows "B" against the spring plunger. If temperature falls, the bellows contracts and releases the pressure on switch "A" which causes current to be switched on.

Switch "C" is an auxiliary pin plunger type switch, also operated by bellows "B". It is actuated by adjusting screw "D" on lever arm "E" and is operated only in case expansion of the bellows fails to operate switch "A".

Incubators for hatching poultry eggs depend on constant, precise regulation of temperature. Deviation of as little as half a degree, if long sustained, means loss of an entire setting.

That is the reason the Reliable Incubator and Brooder Company of Quincy, Illinois, selected Micro Switch snap-action switches as the monitors to insure the even temperature on which the success of their products depends.

Reliable Incubator and Brooder Company provides two switches as an additional safety check. Should lightning strike the line and cause the switch points to fuse together, a second standby switch will take over. The overtravel plunger on the main switch permits further expansion of the bellows to operate the standby switch and at the same time operate an alarm bell.

This application makes excellent use of the small, compact size of Micro Switch products and their ability to handle up to 10 amperes of current at line voltage without the use of relays.

Because of their long life and rugged dependability, designers and engineers in almost every branch of industry are using Micro Switch snap-action switches for limits, safeties and interlocks. A full line of housings and actuators make them applicable under all conditions where a tiny, precise, completely accurate switch is required to handle substantial amounts of power at line voltage.

Your engineers should know all about Micro Switch controls. Send for as many copies of Handbook-Catalog No. 60 as you need. If you are designing for aircraft, send for Handbook-Catalog No. 71 also. Write today.

© 1945 First Industrial Corporation

MICRO MS SWITCH
TRADE MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

Freeport, Illinois, U. S. A., Sales Offices in Principal Cities

Buy More War Bonds

To Finish the Job!

The basic switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a. c. Capacity on d. c. depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.

WASHINGTON

Latest Electronic News Developments Summarized
by *Electronic Industries'* Washington Bureau

OCTOBER TO BE STARTING POINT—Wrangling over postwar price levels for receivers (end-equipment) and tubes and parts with the OPA economists and attorneys occupied the radio-electronic manufacturing industry leadership during much of September. But the time was not seriously wasted, although there was some delay in set production due to the price controversy. However, actually, the industry had to occupy itself largely with the tasks of redesigning of the civilian home receivers, components and tubes and the difficult and huge assignment of settling the military contracts, inventorying, determination of armed forces' surplus and other "cleaning-up" duties resulting from the end of war.

CIVILIAN PRODUCTION STILL DRIBLETS—Because the parts manufacturers were dissatisfied with the OPA price levels, only 5 to 10 per cent of the orders of end-equipment manufacturers were filled in September and tube manufacturers with a similar unsatisfactory price determination generally confined their output to limited quantities mainly for design, except that maintenance-repair tubes with the quotas and M-R markings removed flowed into retailers in larger quantities. During the latter part of October and November and December, provided the price ceilings were acceptable, the industry promised to place by the end of the year on the civilian market anywhere from 2 to 4 million receivers.

TRANSMITTER PRODUCTION—In the case of broadcasting station transmitters, the FCC's assignment of FM frequencies in the new bands to the new stations created a temporary confused situation, but during October when most of the new station applications are to be processed through the Commission, FCC officials anticipated production of FM transmitters will get under way. However, except for one big company's pledge of earlier production, it will take about 6 months for the delivery of the higher-power FM transmitters.

FOREIGN TRADE PROSPECTS BRIGHT—Radio-electronic equipment bulks big among major items of foreign nations sought from the United States, according to a canvass by Electronic Industries' Washington bureau of embassies and legations of leading foreign nations. Much of the apparatus to be purchased in the United States will be financed through loans by Uncle Sam's Treasury through the Export-Import Bank and other American governmental agencies. Russia (which will pay its own cash) has a substantial radio expansion program in its new 5-Year Plan; China has a most ambitious plan for covering its vast areas with radio-communications and broadcasting stations, the cost to run into hundreds of millions of dollars; France and Turkey likewise contemplate substantial purchase of radio equipment; and several Latin American countries have announced similar plans. The Army and Navy radio stations throughout the world gradually will be declared as surplus and sold generally to the foreign nations where they are located; UNRRA will also consume much of this military surplus, planning to use radio apparatus in such communications-sparse countries like Jugoslavia.

MILITARY SURPLUS FLOOD IN U.S. SOON—Disposal of the Army and Navy surpluses is becoming more and more of a thankless task; and some of the original RFC officials realizing this have returned to former assignments out of the Surplus Property Board. However, the plan of President Truman for the single Surplus Administrator (Symington, Lincoln Electric President who knows something of radio equipment problems), instead of the three-man board, has led to the creation of some order out of the previous chaos. Radio-electronic surpluses also were placed under a single top SPB official, Deputy Administrator Schwartz. The alignment of the industry's end-equipment, parts and tube manufacturers as authorized disposal agents for the surpluses has laid the firmest possible foundation for the handling of the excess Army-Navy equipment and components which during the last months of the year are expected to flow in greatly increased quantities.

AVIATION INDUSTRY PLANS HUGE ELECTRONIC PROGRAM—The blueprint for the U. S. Aviation industry and the Civil Aeronautics Administration transition of radio and electronic communications-navigation systems to VHF was plotted in final shape during the last week of September by the Radio Technical Commission for Aeronautics, headed by Bureau of Standards' able radio chief Dr. J. H. Dellinger. Aeronautical Radio, Inc., the cooperative radio organization of the airlines, coordinated the planning for the latter and the FCC aided in freeing the aviation frequencies, held by the military services during the war, for civilian usage. Manufacturers can anticipate an aviation program of many millions of dollars. Example: United Air Lines alone plans a $10 million expenditure in next few years.

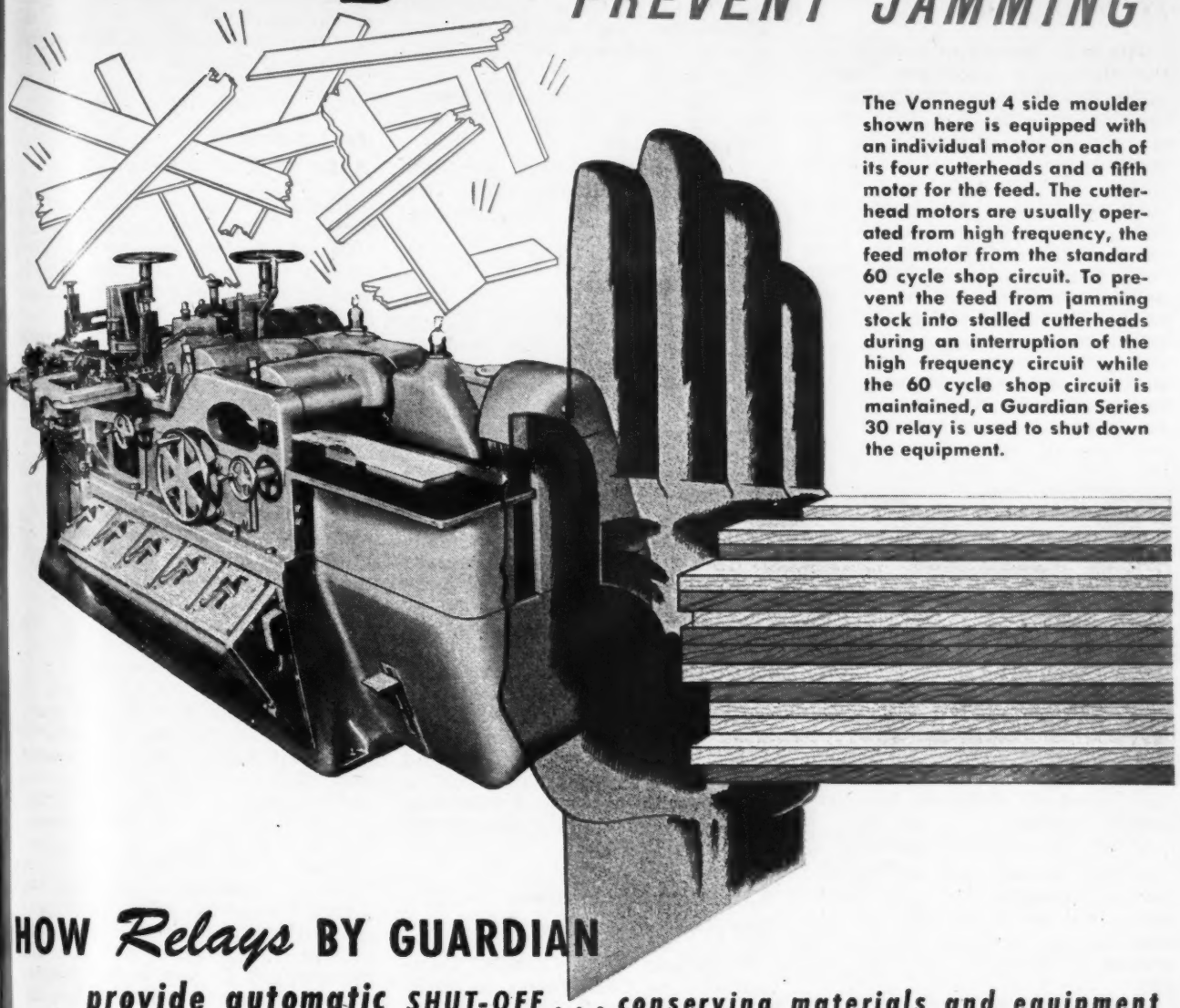
CONGRESSIONAL TRENDS—"Reconversion" session of Congress presents two most significant issues for our industry—wages and full employment legislation and proposal for a National Research Foundation. Too much of a swing to a greatly-shortened work week with maintenance of high wartime wages will kill chances of nation's reconversion and, even though left-wing government officials and labor union leaders advocate this, Congress is felt certain to keep an even balance of economics. The National Research Foundation which President Truman assures will not compete with private enterprise research does offer threat that the comparatively small Federal sums proposed in this venture would mushroom to huge amounts if pressure groups in the scientific world launched drives for allotments.

National Press Building
Washington, D. C.

ROLAND C. DAVIES
Washington Editor

relays IN MACHINE CONTROL

PREVENT JAMMING



The Vonnegut 4 side moulder shown here is equipped with an individual motor on each of its four cutterheads and a fifth motor for the feed. The cutterhead motors are usually operated from high frequency, the feed motor from the standard 60 cycle shop circuit. To prevent the feed from jamming stock into stalled cutterheads during an interruption of the high frequency circuit while the 60 cycle shop circuit is maintained, a Guardian Series 30 relay is used to shut down the equipment.

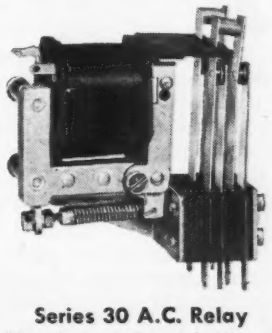
HOW *Relays* BY GUARDIAN

provide automatic SHUT-OFF . . . *conserving materials and equipment*

Wherever two or more independent sources of power are utilized to perform one operation, the failure of one power source presents a hazard to safety, materials and equipment. In such places Relays by Guardian are often employed to interrupt all other circuits when one circuit fails.

The Vonnegut 4 sided moulder, built by the Vonnegut Moulder Corporation of Indianapolis, uses a Guardian Series 30 relay in this application. This is a quiet, dependable relay with a laminated field piece and armature, a large contact switch capacity, and a wide operating range. It is available for operation on any frequency between 20 and 150 cycles.

But whatever your relay application may be, it will pay you to write. If you describe your application when writing, Guardian engineers will make recommendations.



Series 30 A.C. Relay

Also, iron clad and laminated solenoids, stepping relays, magnetic contactors, electric counters, snap and blade switches.

GUARDIAN ELECTRIC

1622-L W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

DEVELOPMENTS IN THE FM FIELD

FCC's FM Rules

The most important issue among the rules and regulations formulated for FCC for governing FM broadcasting was the assignment of additional channels to the northeastern section of the United States. The number of available channels for the heavily populated New England area was raised from 170 to 180 by taking over the 2 mc from the 106 to 108 mc band heretofore reserved for facsimile broadcasting which now moves up to 470 to 480 mc.

This action gives the New England section as many rural and metropolitan FM stations as there are AM metropolitan stations at the present time (either high or low power). In addition, there will be spectrum space for 30 per cent more community FM stations than there are existing AM stations in that category. Generally speaking, sixty channels have been allocated for metropolitan and rural stations having a power of 20 kw and a 500-foot antenna. Twenty channels have been assigned to the small community stations which will have 250 watts of power and 250-foot antenna. The remainder of the nation will have 70 channels for metropolitan and rural stations, and 60 channels for community stations.

Other rules promulgated are:

1. FM stations will be licensed for an unlimited time and during the initial period of existence the new station will be required to operate a minimum of six hours per day.

2. No rule was set up concerning the time element for program duplication.

3. No. person may own more than one FM station in the same community, and no person may own more than one FM station in separate communities except on proper showing and in no event may one person own more than six FM stations.

4. No rule has been made regarding the ownership of an FM station by an AM station owner.

5. AM chain rules will apply to FM.

6. Sharing of antenna sites will be required when no comparable antenna site is available. The FCC feels that this rule will prevent any station operator from sewing up a market area by the control of an antenna site.

7. No rules regarding booster stations. The FCC points out that applications for booster stations will be considered on their individual merit.

8. The Commission is not reserving any future channels for FM at the present time.

9. FM stations will be permitted to transmit facsimile during the hours they are not on commercial broadcasting.

HF FM By '46

FCC's recent notice to the six FM license holders to be ready to go into operation in the new 92 to 108 mc strip by the first of the year, and to start field tests on the new assignments by December 1, is interpreted as an attempt to speed up the change over from the old to new spectrum positions. The holders of the seven construction permits so far issued must be ready to start field testing by January 1 and to enter operation by February 1 under new assignments.

Of the 500 FM applicants, the FCC pointed out that licenses will be granted, along with permission to operate at a lower power than the license stipulates, until equipment is more easily obtainable. However, applicants are requested by the commission to submit a complete statement on transmitter location and antenna site within 30 days.

FM Communication for Bus Services

Permission of the Federal Communications Commission to equip up to 100 intercity buses with FM two-way radio communication and to operate a central control transmitter is being sought by Intercity Bus Radio, Inc., a division of the National Association of Motor Bus Operators, Chicago. The experiment is being undertaken by the Greyhound Corporation in cooperation with several other intercity bus lines running into Chicago. Unless delays are encountered in the granting of licenses, the complete system will be in operation within 90 days.

The tentative plans, which are expected to lead to the development of a nationwide system of two-way radio communication on highway buses, provide for the operation of a 250-watt central transmitter in the Chicago Loop. The buses will be equipped with 50-watt transmitters, combined with receivers. Greyhound plans to install the radio sets on buses of four of its lines—Pennsylvania, Central, Northland and Illinois—running into Chicago. Similar equipment is expected to be placed on the coaches of several other operating companies. In addition, there will be three relay receiving stations located in outlying sections of Chicago.

Jett Advises AM-FM Radio Sets

Radio listeners were advised by Federal Communications Commissioner E. K. Jett, in a recent radio speech, to buy combination AM-FM sets when the new models appear on the market.

Declaring that the speed with which FM broadcasting develops will depend on "how rapidly you, the listeners, accept this new method of program transmissions," Commissioner Jett said:

"During the transition period from AM to FM most of the receivers offered for sale to the public will incorporate both systems of broadcasting. The added cost for the FM feature will not be great—perhaps no more than you have been accustomed to pay for the short-wave international broadcasting range in your existing pre-war receiver. It is, therefore, to your advantage to obtain a combination set which will receive both AM and FM when the new models appear on the market. If your present receiver is in good condition you may wish to consider purchasing an FM adapter, or a receiver capable of FM reception only."

Commissioner Jett predicted that within four or five years after civilian production is resumed "at least half of the homes of America will be equipped to receive FM broadcasts." In metropolitan areas, he said, "FM eventually will replace local and regional AM reception." However, he added, the high-power clear-channel AM stations "must be retained throughout the years to serve rural audiences which cannot get good reception from FM stations."

Tubes in 1946 Sets

Tube complements to be required in the new 1946 radio sets with FM bands and television reception, as compared to pre-war sets, are estimated by Raytheon's L. K. Marshall as:

	Number of Tubes
Pre-war radio set in $50 retail price range	6- 8
Comparable new set with FM band	8- 9
Low-cost television set	18-20
High-quality television set with FM band and record changer	25-30

"CONFIDENTLY, SMITHERS, BOSCO IS A COIL HOUND. HE SHOWS US WHERE WE CAN GET ALL THE COILS WE NEED"

SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

ALBION
COIL COMPANY
ALBION, ILLINOIS

R. F. AND TRANSMITTING COILS AND CHOKES;
I. F. TRANSFORMERS

WHAT'S NEW

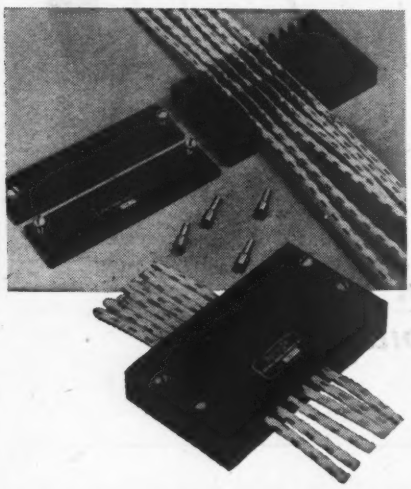
Devices, products and materials the manufacturers offer

Circuit Breaker

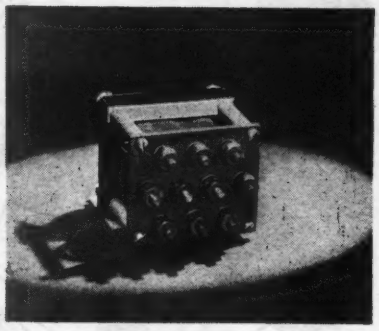
A new double pole circuit breaker, designed for service on 230 v ac or 250 v dc, 50 amps maximum, is being manufactured by the Heinemann Circuit Breaker Company, 137 Plum Street, Trenton, N. J. Unit may be connected either front or rear, will carry full load continuously, and has instantaneous trip at eight to ten times full load. It also has a selection of three time delays, any one of which may be specified. Overall dimensions are: 5¼ in. long by 2 1/16 in. high and 2 in. wide.

Solderless Connector Strips

Connector strips using knife switch disconnect terminals, are being manufactured by Aircraft-Marine Products, Inc., 1591 D No. 4th St., Harrisburg, Pa. Two types are available: (1) Illustrated. The single-width strip adapted for use with the AMP preinsulated splicing terminal which requires no insulation sleeving. The knife switch part



of the permanent member extends outside the strip and connection and disconnection are made without removing the cover of the assembly. (2) The double-width strip in which the disconnect ends are enclosed, locked and insulated by the cover, one-half of which is independent of the other half. Disconnection is made by unscrewing only one half of the cover to expose the connections. Special stacking screws with threaded heads make it possible to permanently stack a series of AMP strips with the cover screwed on top. The strips can accommodate any desired number of connections. Any combination of adjacent members may be electrically connected.



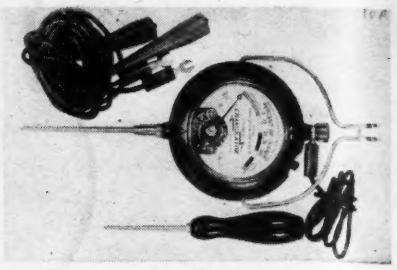
Aircraft Transformers

Two new 115-volt, 400-cycle, single-phase transformers, designed to operate 6-volt aircraft-instrument lights, are being manufactured by General Electric's Specialty Transformer Division, Schenectady 5, N. Y. With an output capacity of 30 volt-amperes, either of these units permits simultaneous operation of 25 lamps at full brilliancy. One of the transformers is provided with taps which facilitate the preselection of any desired light level within the unit's range of 6 to 1.74 volts. The taps are so arranged that each successive voltage reduction approximately halves the previous candlepower output of the lamps. Taps are not provided on the other unit, but any desired light level can be maintained by using a potentiometer. Both transformers are light in weight—the tapped unit weighing 1 lb. and the other 0.8 lb.—and were designed for convenient mounting and connecting. The mounting clamps are protected against corrosion and the terminal boards are constructed of vibration and shock-resistant material.

One-Piece Fastener

A new one-piece fastener assembly, which does not require nuts or receptacles, has been developed by the Simmons Fastener Corp., Albany, N. Y. Self-adjusting to compensate for various material thicknesses within the range of the fastener, the fastener locks and unlocks with a quarter-turn in a 90 degree clockwise rotation, or can be

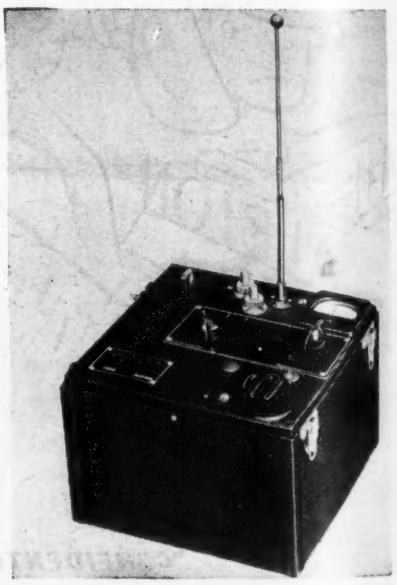
permanently installed for use as a blind rivet. Standard size fasteners are ⅛ in., 5/32 in., 3/16 in., ¼ in. and 5/16 in. The range of material thicknesses go from nothing to 3/16. in. total on the largest fastener.



Hydrometer Substitute

The Hickok Electrical Instrument Co., 10528 Dupont Ave., Cleveland 8, Ohio, has developed a unit that indicates electrically the equivalent gravity of lead-acid storage batteries. The Chargicator unit gives instantaneous measurement of battery condition, and shows what charging rate to use, either for trickle charging or for a safe, high rate charge. Also indicated are the percentage of charge, and over-charging danger. Weak or defective cells are readily spotted. A large 4-color scale is used. All models are sealed within molded acid-proof bakelite cases and are not affected by weather or temperature.

Checking Oscillator

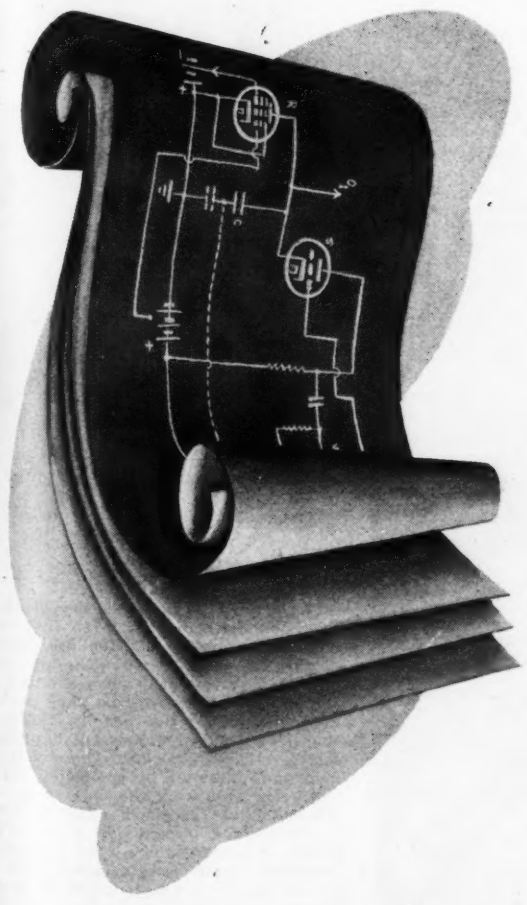


Type 291 is a portable, battery operated oscillator especially and primarily designed for checking HF aircraft radio receivers. As such, all features and equipment not relating to checking aircraft receivers have been omitted, resulting in a specalized, good quality checking oscillator at low cost. This new instrument has a frequency range from 49 to 154 megacycles with modulation frequencies of 70, 90, 400, 1300, and 3000 cycles. It contains an easily extended, collapsible antenna and two coaxial terminals for low and high level output. Maker is Andrew Co., Chicago 19, Ill.

Dynamic Mike

Universal Microphone Co., Inglewood, Cal., has reissued its prewar KD dynamic microphone for home recording, industrial call systems and public address systems. Frequency response is 50-7500 cycles per second; output level 63 db below one volt per bar; impedance 40,000 ohms. The KD is finished in deep bronze plating; includes 10 ft. rubber covered cable.

Specialized Knowledge and Equipment for UHF DESIGN



● The phenomena encountered in the UHF field are in many cases so decidedly different from those true of lower frequencies that many manufacturers find themselves in urgent need of specialized UHF knowledge, in order to develop equipment that will handle certain specific conditions.

● Since we are specialists in UHF engineering, we are equipped not only to render technical advice, but also to follow through in the actual production of equipment in our shops.

● Of necessity, during the war period, our efforts have been concentrated largely on Army and Navy work. Now that peace is with us, we have adequate time to devote to civilian requirements. We invite discussion of any problems you may have in the UHF field.

U H F

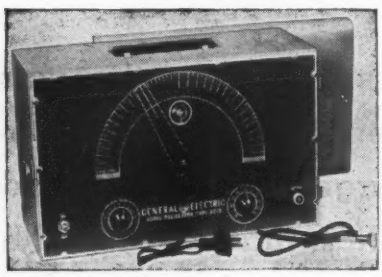
Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in The Development of UHF Equipment
and in The Manufacture of UHF Antennas

Resistance Limit Bridge

A resistance limit bridge (LB-3) working to plus/minus .1 per cent is being manufactured by Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J. The bridge has high and low limit dials covering a range of plus/minus 11 per cent in .1 per cent steps, and uses a sensitive built-in galvanometer to provide for the high and low indication, respectively.



Audio Oscillator

A new beat frequency audio oscillator, Type AO-2, has been developed by the Specialty Division of the General Electric Company's Electronics Department, Schenectady, N. Y. The unit has been designed to simplify the measurements of audio amplifiers and radio receiver fidelity. Using full vision and making possible direct calibration, the unit provides a stable sine wave, continuous variable frequency from 25 to 15,000 cycles per second. The panel control knob regulates the output level from zero to full power output. A Type 6E5 Electron-ray Tube is used to indicate zero beat while adjusting the panel control knob to obtain the proper relationship between the two high frequency oscillators. The maximum output is 120 milliwatts on the cathode follower type output impedance coupling circuit.

Regulated Power Supplies

A new series of saturable reactor regulated power supplies has been developed by the Amplifier Co. of America, 398 Broadway, New York 13, N. Y., for all applications requiring dc voltages regulated to better than 5 per cent from full load to no load, and having less than 1 per cent ripple under full load conditions. Included in this new series are the following standard power packs, which may be supplied with built-in automatic voltage regulators: 24 v ½ amp; 24 v 2 amp; 48 v 1¾ amp; 48 v 5 amp; combination 24 and 48 v 750 mil; 36 v 1 amp; 110 v 8 amp; 120 v 200 mils; 135 v ½ amp; 250 v .4 amp; 500 v 200 mils. Power packs employing heavy-duty rectifier tubes are provided with built-in thermal time delay relays which apply plate supply voltage approximately 30 seconds after rectifier filaments are heated. All power packs are equipped with recessed male receptacles, female outlets, power line switch, pilot indicator and fuse.

Thermoset Plastic

A new non-flammable thermoset plastic with high optical and electrical properties, good resistance to abrasion and high resistance to oils and greases and most chemicals, including acids and alkalies, has been developed by the B. F. Goodrich Chemical Co., Cleveland. The new material has been named Kriston. Kriston monomer is a somewhat viscous, water-clear, anhydrous liquid having a specific gravity of 1.25 and can be cast in simple molds. It sets to a hard, heat-resistant plastic. No water or other volatile products are released during the polymerization, making easy the preparation of dense, non-porous articles. Shrinkage during polymerization is substantially lower than that of any other known material of the type.

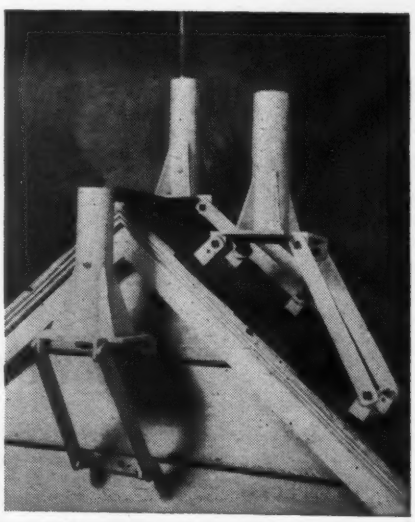
Kriston polymer has a refractive index of about 1.57. This is higher than most optical glass. The material can be made into a water-clear plastic or made in a wide range of colors which can be transparent, translucent or opaque. In its cast state, Kriston is odorless, tasteless, nontoxic, and dimensionally stable. After molding it can be worked on standard machining and polishing equipment.

Colortone Mikes

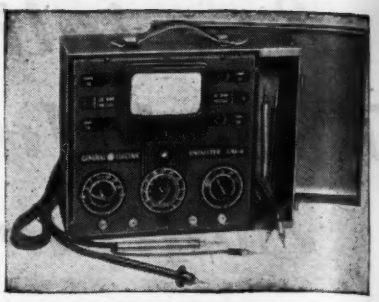
Inspired by the growing demand for color harmony in modern living, business and entertainment, the Turner Co., Cedar Rapids, Iowa, is introducing a new line of crystal and dynamic microphones in color, styled by Arthur C. Haggstrom, noted industrial designer. The material selected for the "Colortone" cases is a tough, resilient cellulose acetate. These plastic castings can be produced in a wide variety of rich, gem-like colors, including solid colors and pastels, mottles and striated effects.

Antenna Mount

A mount for FM and television antennae is being manufactured by Shur-Antenna-

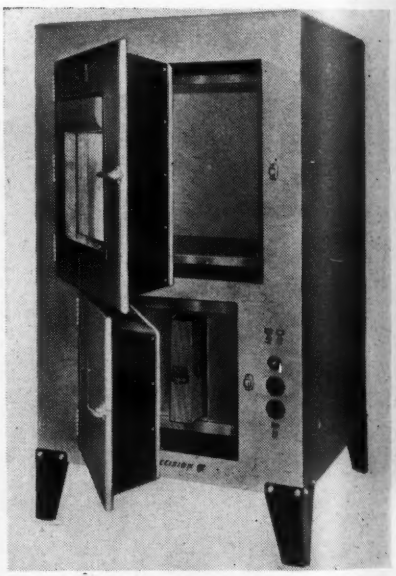


Mount, Inc., 272 Sea Cliff Ave., Sea Cliff, N. Y. The unit will fit any roof top, and is suited for all types of surfaces. .It will sustain the weight of any fixed standard FM or television antenna array.



Multirange Instrument

A new multirange instrument, Type UM-4 Unimeter, has been developed by the Specialty Division of the General Electric Company's Electronics Department, Schenectady, N. Y. The new device is equipped with special jumbo test prods and has a wide coverage of ranges. On dc it operates from 0 to 10,000 volts at 20,000 ohms per volt. On ac it ranges from 0 to 10,000 volts at approximately 5,000 ohms per volt. Direct-current ranges extend from 100 microamperes to 10 amperes in six steps and resistance measurements are provided from 3,000 ohms to ten megohms in five steps.



Cooling Cabinet

A cold cabinet has been developed by the Precision Scientific Co., 1750 N. Springfield Ave., Chicago 47, Ill., for use from —90 deg. F. to + 220 deg. F. The unit uses dry ice. A 7-pane sealed window unit prevents condensation and frosting, and makes the apparatus under test readily visible at all times. A shielded fluorescent light prevents direct and indirect glare. Thermal losses are kept at a minimum by completely insulating the inner wall from the outer wall. An air stirrer, in the specimen chamber holds the temperature constant ± 1 deg. F. A blower circulates the air to and from the chamber. Metal plates 4 in. wide, the height of the chamber, are centered on each side, in the rear, and on the top, to provide facilities for mounting the test apparatus from any of these positions. Cabinet is available in 2 sizes: 1 cu. ft. capacity and 8 cu. ft. capacity. The 1 cu. ft. box is 53 in. high, 26 in. wide, 26 in. deep. The capacity of the dry ice trays is 15 lbs. The 8 cu. ft. box is 73 in. high, 39 in. wide, 39 in. deep. The center of the test chamber, which is 24 in. x 24 in. x 24 in. is located at an operating height of 48 in.

SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

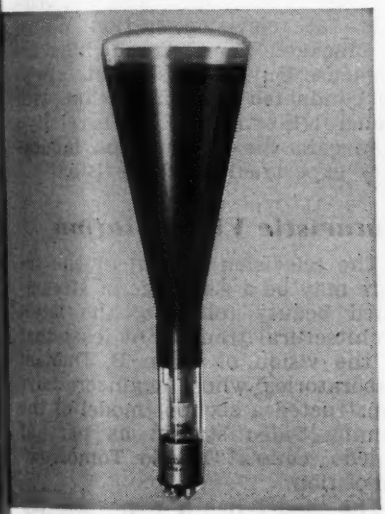
OCT. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1945

SYLVANIA CATHODE RAY TUBES NOW AVAILABLE

Ready for New Television Sets To Be Produced

Sylvania Electric announces the welcome news that cathode ray tubes are once more available for the manufacturers of television sets.

Constant research in this field, combined with wide experience in large-



Sylvania Electric precision-built cathode ray tube now available to television set manufacturers.

scale production to meet war requirements, has placed Sylvania in a position to manufacture these tubes to a much higher standard than ever before.

This is an important factor to manufacturers of television receivers whose "plans" are rapidly becoming realities.

Check today with Sylvania Electric Products Inc., Emporium, Pa.

MANY MANUFACTURERS TO USE ELECTRICALLY SUPERIOR TUBE

Sylvania Lock-In Radio Tube Ideal For FM, Television, Radar

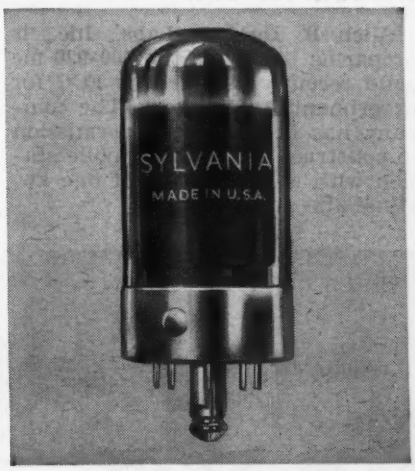
With the increasing trend toward higher frequencies—as shown by recent FCC decision assigning FM the band between 88 and 106 megacycles—set manufacturers will tend, more than ever, to use a tube ideally suited to the adoption of these very high frequencies.

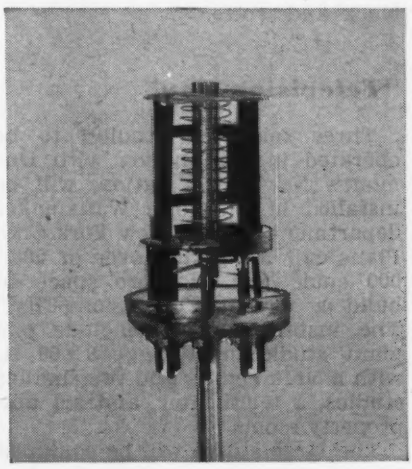
The Sylvania Lock-In is *known* to be electrically and mechanically superior to any tube made.

Electrically, it is more efficient because the element leads are brought directly down through the low-loss glass header to become sturdy socket pins—reducing lead inductance—and interelement capacity.

Mechanically, it is more rugged because support rods are stronger and thicker—there are fewer welded joints and no soldered joints—the lock-in lug is metal, not molded plastic—the elements are prevented from warping and weaving.

Today, set manufacturers considering the many developments in the field of communications, are looking to the Sylvania Lock-In Tube as a perfect electronic unit—the tube built to handle ultra-high frequencies.





The Sylvania Lock-In Tube showing construction—electrical and mechanical—that makes it superior to any tube made.

SYLVANIA ELECTRIC

Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS

★ TELEVISION TODAY* ★

New Developments in the Video Field

CBS Color Plans

Some additional light has been let in upon Columbia Broadcasting Company's shortly-to-be-inaugurated television experiments at high frequencies. Some time ago it was announced that CBS had authorized Federal Telephone and Radio Corp. to produce a new transmitter to operate between 480 and 500 mc that it is now expected will be installed in New York's Chrysler building and ready for operation some time in December. Meantime, General Electric has authorization for another transmitter which it is stated may be installed either in Chicago or Hollywood, both locations having been applied for to FCC.

According to present CBS plans, experimental transmissions of both color and high definition black and white pictures will be started in New York as soon as the transmitter installation is completed. For the present no change is contemplated in the CBS fundamental method of transmitting color through the medium of a rotating disk. The disk itself has been considerably improved, is understood to be somewhat smaller and to operate silently. At the same time, work is progressing on the design and construction of several types of receivers which will be suitable for the reception of both color and black and white.

"Television City"

Three television studios, to be operated in conjunction with Dumont's New York station, will be installed in the John Wanamaker department store in New York City. Plans call for taking over of 500,000 cubic feet of store space to build a virtual "Television City." The installation will include one giant studio measuring 50 x 60 ft. with a 50 ft. ceiling and two smaller studios, a teletheater, and art and property rooms.

The large studio will be equipped with four cameras while the two smaller studios will handle three and two cameras respectively. The three studios will be separated by soundproof walls and doors to permit simultaneous use of the three, even though one may be on the air.

The department store television production center will offer larger accommodation facilities for live audiences than any other television station in the country. A balcony above the studio floor will seat 400 visitors and a platform around the balcony will handle 200 standees. A glass wall at the rear of the studio will permit shoppers to watch daytime and evening rehearsals and broadcasts.

50 Kw for W6XAO

Don Lee television system, Los Angeles, will replace its present 2 kw W6XAO on Mt. Lee with a 50 kw station on Mt. Wilson, elevation 5800 ft. The present site will be used for relay and studio purposes. The new equipment was ordered from General Electric Co., before the surrender of Japan. W6XAO (KTSL) has been on the air since December 1931 under the engineering direction of Harry R. Lubcke. In addition to fulfilling war contracts there have been fortnightly broadcasts of live and film shows during the past 3 years. Mt. Wilson has also been selected as the site for at least five other television stations to be erected in the Los Angeles area.

DuMont HF Tele

Allen B. DuMont Labs., Inc., is preparing to invade the 480-920 mc band recently assigned by FCC for experimental video work. The company has been granted permission to construct a portable-mobile station with a peak power of one kw, visual and aural.

Educational Video

Television as a medium of education will have its first tryout this fall in a series of experiments to be conducted by three institutions of learning—the New York Board of Education, Chicago Board of Education and Syracuse University.

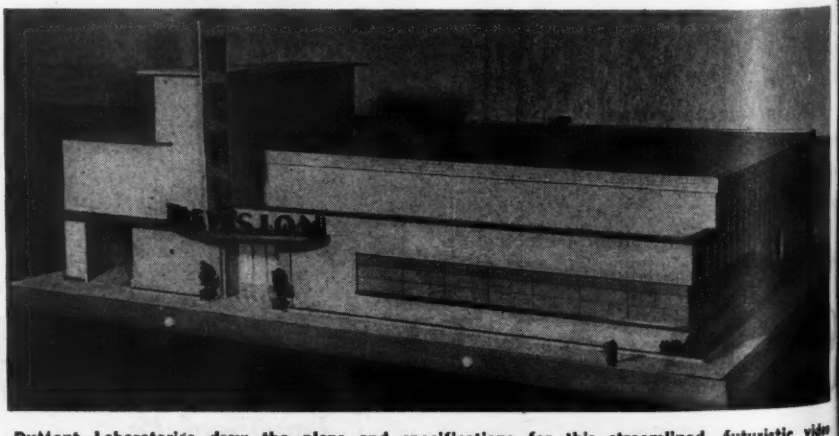
The New York test was scheduled to start as soon as school resumed and be conducted in conjunction with the National Broadcasting Co. The experiments were to originate at NBC's television outlet WNBT and be received by specially installed large screen receivers in classrooms in various schools throughout the city.

The Chicago tests are scheduled to start in sixty days and will originate at television station WBKB in Chicago. The tests scheduled for Syracuse University students are to be conducted in conjunction with General Electric. The University's plan calls for lecturing on laboratory experiments by television.

Futuristic Video Station

The television station of the future may be a structure of streamlined beauty following the latest architectural trends. At least that is the vision of Allen B. DuMont Laboratories, whose engineers have constructed a six foot model of the coming video station as part of Toledo, Ohio's "Toledo Tomorrow" exposition.

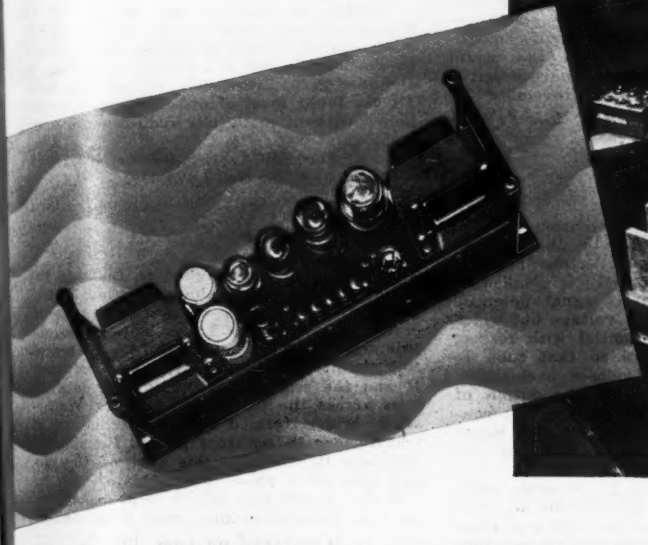
The model has a removable top which allows views to look inside. The interior of the miniature is complete to the smallest detail, including studios, control rooms, transmitter rooms. Studios have accommodations for forty guests.



DuMont Laboratories drew the plans and specifications for this streamlined, futuristic video station. It represents the last word in the efficient arrangement of studios and equipment

*Title registered U. S. Patent Office.

A HARVEY Regulated Power Supply 106 PA . . .



Helps RECORD A SUBTERRANEAN RESERVOIR'S REACTIONS

This Petroleum Reservoir Behavior Analyzer, developed by a major oil company, is used to analyze the behavior of petroleum reservoirs and predict the future performance of these reservoirs under arbitrarily assumed conditions of reservoir control. It makes automatic computations in a matter of minutes that would take a dozen mathematicians several months.

A *HARVEY Regulated Power Supply 106 PA* like the one pictured plays an important role in the operation of this amazing device. To perform efficiently, the Analyzer must have a constant source of static-free regulated power. The HARVEY 106 PA has proven a dependable, controllable source of this power.

The *HARVEY Regulated Power Supply 106 PA* provides laboratory D.C. power between 200-300 volts. Operates from 115 volts A.C. . . . output remains constant even though line voltage varies between 95 and 115 volts. Ripple content is better than 10 MV . . . two separate filament voltages available, 6.3 volts, 5 amps. each . . . parallel operation possible making 6.3 volts at 10 amps. available.

If you operate equipment requiring a constant source of laboratory D.C. power— pulse generators, amplifiers, measurement equipment, constant frequency oscillators and the like — you should have complete information on the HARVEY 106 PA on hand. Write for HARVEY Regulated Power Supply Bulletin H-25 today.

HAR-CAM
HARVEY OF CAMBRIDGE

HARVEY RADIO LABORATORIES, INC.

441 CONCORD AVENUE · CAMBRIDGE 38, MASSACHUSETTS

NEW PATENTS ISSUED

Pulse Modulation

It is proposed to transmit short pulses separated by comparatively large spaces, and to modify the relative timing of successive pulses in accordance with the modulation voltage. Thus, if successive pulses are numbered 1, 2, 3, 4, 5, etc., one polarity of modulation potential moves pulses 1 and 2, 3 and 4, 5 and 6, etc., closer together but moves pulses 2 and 3, 4 and 5, 6 and 7, etc., further apart by an equal amount (see diagram at lower right-hand corner). Reversing the modulation potential will reverse the time displacements of successive pulses. There is no change in average pulse rate.

By operating the communication system of the invention so as to transmit short pulses separated by relatively long spaces, the following desirable results are achieved: (1) Higher peak power and much higher frequencies than would otherwise be possible because of limitations due to heating of the transmitter tubes, (2) an improvement of signal-to-noise ratio in view of the fact that the receiver is responsive only during time periods which may be occupied by the transmitted pulse, and (3) a degree of secrecy in signaling.

When the pulsing tubes in the transmitter circuit become non-conductive simultaneously, the power source potential is applied to the transmitter. With no modulation applied, one or the other of the pulsing tubes passes current at all times except when the input from the constant frequency source is near the zero value. For near zero values both tubes are simultaneously cut off and a short current pulse at relatively high potential is passed into the transmitter. These pulses are uniformly spaced.

Modulation produces a variation in the bias potential of both grids in opposite directions, drawing alternate pulses together; reversal of modulation potential polarity will cause the pulses to be pushed apart, as illustrated in the figure.

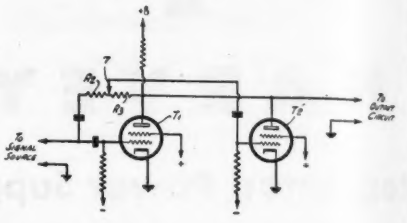
The receiver incorporates two pulsing oscillators similar to those used to produce sawtooth potentials in television receivers, each adjusted to 7,500 cycles. They are provided with a common plate resistor for the purpose of making them tend to operate substantially 180 deg. out of phase. The received pulses are utilized to synchronize the operation of the pulse oscillators and, obviously, alternate received pulses are automatically effective in controlling the timing of each oscillator. When a received pulse advances the time of tripping of one oscillator, it retards the time of tripping of the other. In effect, the received pulses modulate the phase or timing of oscillations of each pulse oscillator but not the oscillation frequency; they vary the average current through the tubes. Once the oscillations have dropped into synchronism with the received pulses, the average plate current will be modulated by the pulse modulation. This current provides the useful output for the headphone or a recorder.

C. W. Hansell, RCA, (F) November 29, 1940, (I) July 10, 1945, Nos. 2,379,899 and 2,379,900.

Amplifier Circuit

It is the object of the invention to eliminate harmonic distortion in an amplifier output without reducing its gain. For this purpose, the grid of tube T_2 is coupled to point 7 which is at zero signal potential with respect to the signal voltage but which is at an appreciable potential with respect to the distortion voltage so that tube T_2 amplifies the distortion voltage exclusively. Its output is combined with the output of amplifier tube T_1, the combined output containing no distortion voltage; the signal voltage amplitude is not affected by the addition of tube T_2.

The value of R_2 plus R_3 is made sufficiently large so that no appreciable negative feedback occurs between the grid and plate of T_1. The relative magnitudes of resistors



R_2 and R_3 are so dimensioned that at the junction point 7 the signal voltages from the plate and the grid compensate one another, or R_3 is equal to R_2 times the amplification factor of tube T_1; no signal voltage will then be applied to tube T_2.

Assume an amplifier with a gain of 10 and 10 per cent distortion. If approximately 1 per cent distortion is desired, conventional feedback calls for a 10 to 1 reduction in amplifier gain. However, by inserting tube T_2, the lower level of distortion may be attained without materially reducing the original gain.

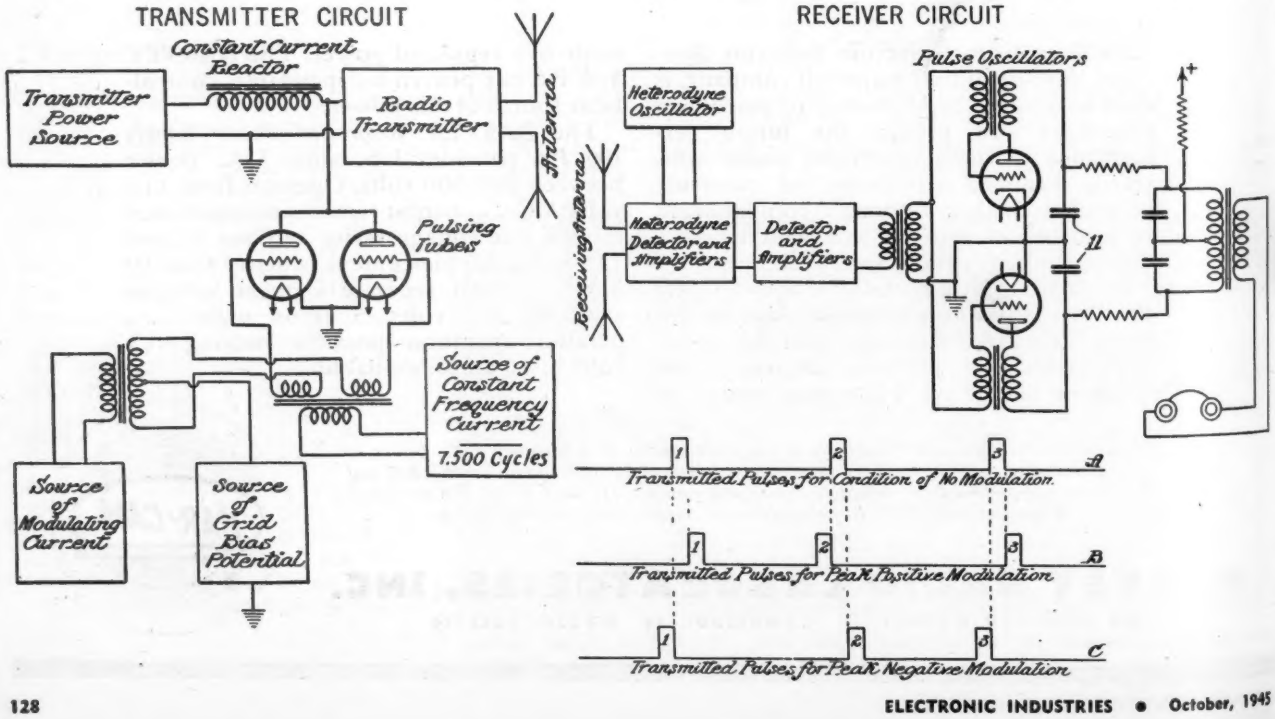
J. R. Ford, RCA, (F) October 13, 1943, (I) July 3, 1945, No. 2,379,699.

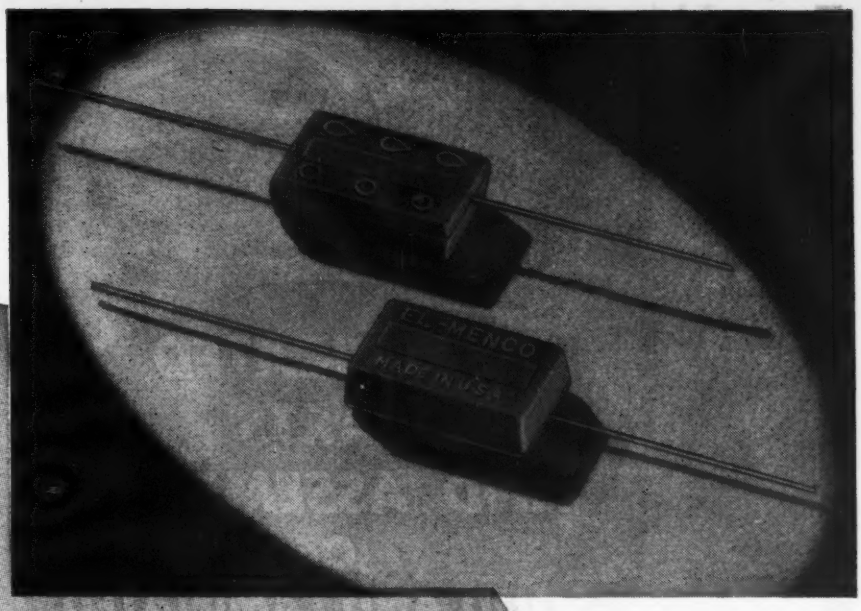
Mine Detector

The circuit was designed to indicate the presence of metallic objects buried underground. Tube L_1 is connected as a generator feeding 1,000 kc oscillations to the primary of transformer M and to the search coil circuit. The secondary of transformer M and the search coil circuit provide voltages across the two diagonals of a Wheatstone bridge formed by the secondary of transformer M, resistors R_2 and R_3, and dry rectifiers D_1 and D_2; this part of the circuit acts as a phase discriminator.

If the search coil circuit is at resonance, the two voltages in the phase discriminator

(*Continued on page* 194)





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BRITISH WALKIE-TALKI

(*Continued from page* 108)

on a typical receiver are given i Fig. 3. Curves of receiver rf selec tivity and audio fidelity are show in Figs. 4 and 5.

The transmitter is a master oscil lator, power amplifier type, tunin the same range as the receive The circuit is shown in Fig. 6 The master oscillator utilizes both electron coupling and frequency doubling. The control grid and screen grid section of a 1A5GT operate as an oscillator at 3 to 4.5 megacycles, and the plate circuit tunes from 6 to 9 megacycles, se lecting the second harmonic of the oscillator. This type of oscillator was found to be extremely stable because of the buffer action of the plate circuit. Single tuning contro is achieved by ganging both the oscillator and plate tuning con densers.

Power amplifie

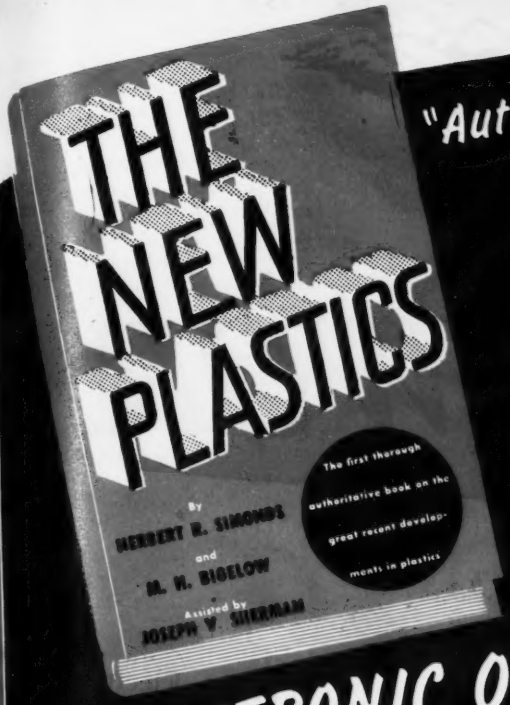
The power amplifier consists o two 1299 tubes connected in paral lel. Two tubes are needed to mee the power output specifications Parallel operation rather than push-pull was used to simplify the buffer and tank coil construction While neutralization of plate to grid capacity is normally unneces sary in a screen grid type amplifier it was found necessary in order completely to eliminate interaction between the power amplifier and master oscillator. When neutralized the change in oscillator frequency due to any variation in amplifier load or tuning, never exceeds 50 cycles per second. The frequency of oscillation is almost completely independent of power amplifier load and tuning variations.

For cw transmission, the 1299 tubes deliver maximum power out put, operating with 150 volts on both plate and screens. For phone operation, the screen voltage is re duced to 60 volts by the insertion of a series resistor between B+ and screen grid.

The modulator system consists o a carbon microphone coupled through the step-up transformer to the grid of a 1LD5 operating as an audio power amplifier. A negative voltage feedback loop from the 1299 screen grids to the modulator grid serves to reduce distortion and im prove the frequency response of the modulator. A curve of distortion versus percentage modulation is shown in Fig. 7, while Fig. 8 is a fidelity curve.

The power amplifier tank coil is equipped with a series of taps available through a selector switch. These permit proper matching of any one of a wide variety of an tennas with which the set must

(*Continued on page* 134)



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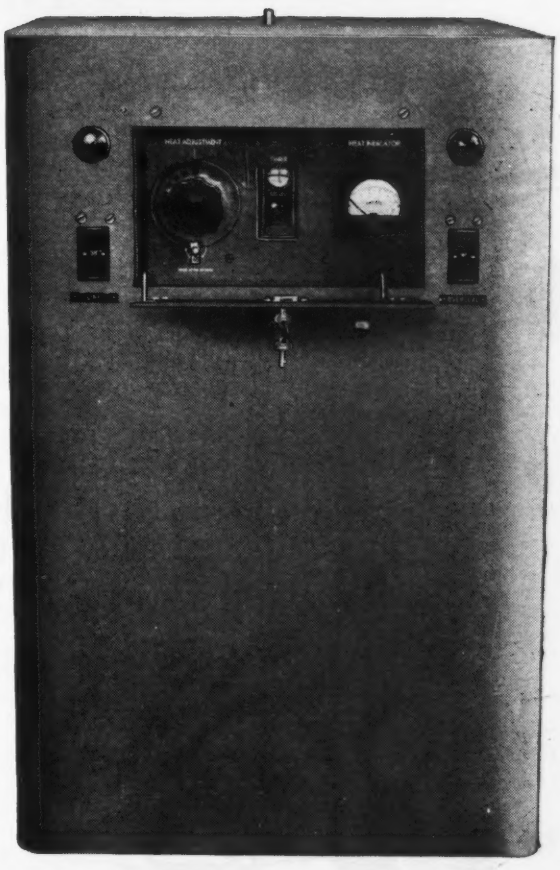
. From THE NEW PLASTICS by Herbert R. Simonds and M. H. Bigelow, published 1945 by D Van Nostrand Company, Inc.



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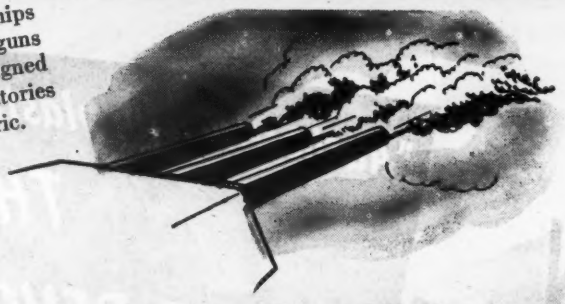
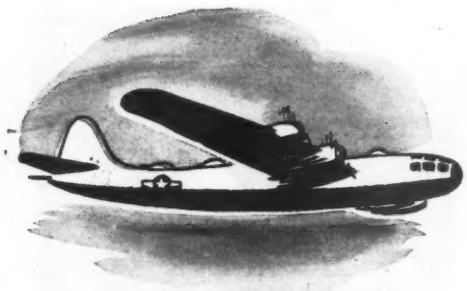
SINCE 1922 IN RADIO AND ELECTRONICS

All of the big guns on Navy ships and a majority of their smaller guns are directed by radars designed by Bell Telephone Laboratories and made by Western Electric.



What TEAMWORK



Bomb-directing radars used on B-29s were designed by the Laboratories and made by Western Electric.

This team developed and produced low altitude radar bombsights widely used against the enemy's merchant shipping.

Bell Telephone Laboratories and Western Electric were "naturals" for the leading part they played in the radar program. For years they've worked as a team in developing and producing complex electronic equipment.

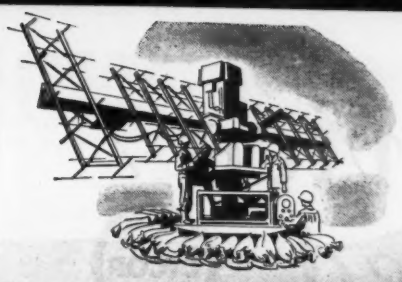
Here are some unadorned facts about what their teamwork made possible.

Up to the end of the war, Western Electric had furnished the Army, Navy and Air Forces with more than 56,000 radars of 64 different types, valued at almost $900,000,000.

In 1944 alone, Bell Laboratories worked on 81 different types of radar systems and Western Electric produced 22,000 radars of 44 different types — of which 20 were new in production that year.

Western Electric was the largest producer of the cavity magnetron and other essential vacuum tubes for radar. Number of tubes required for Western Electric radar systems varied from less than 100 to nearly 400 per system.

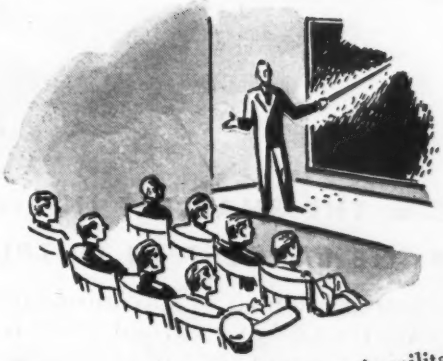
Complexity of radar manufacture is indicated by the fact that even a simple type may require 4,000 labor hours to manufacture and the larger types as much as 40,000 labor hours.



From the very beginning, ground radars made by Western Electric played an important role in all theatres of war.

did for RADAR

Bell Laboratories developed more than 100 different radar test sets. In 1944, Western produced over 40,000 test sets of 68 types.



A school to train military personnel to operate and maintain radar was established by the Laboratories. Over 100 courses were given to some 4,000 officers and men.

The same team is working for YOU!

The unique combination of brain power and manufacturing facilities that made Bell Laboratories and Western Electric the nation's largest source of radar, is now devoted to bringing you the best in communications equipment for a world at peace. In peacetime off-shoots of radar—and in FM, AM and television broadcasting—in radio telephone equipment for every type of mobile service—this team can be counted on to lead the way.

Western Electric built up a Field Engineering Force of more than 500 specialists. They served with all branches of the Armed Forces on all fighting fronts.

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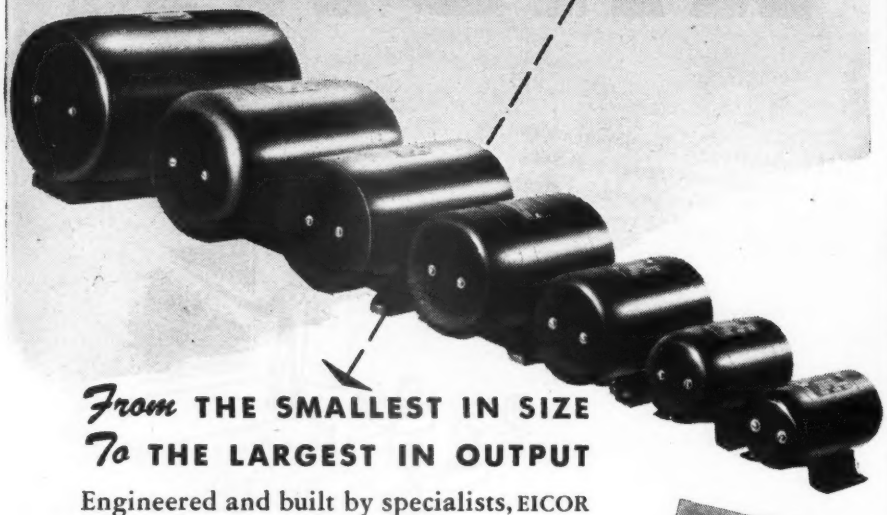

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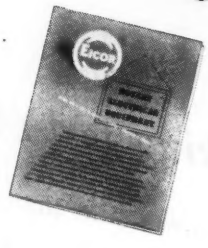

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3400	125	3 7/16 in.	5 5/8 to 8 11/32 in.	4 1/2 to 7 1/2 lbs.
4100	200	4 1/16 in.	6 1/2 to 7 3/8 in.	6 3/4 to 9 lbs.
4500	250	4 1/2 in.	6 1/2 to 8 in.	11 1/2 to 13 1/4 lbs.
5100	350	5 1/8 in.	8 1/2 to 10 in.	17 to 21 1/2 lbs.
6100	500	6 3/16 in.	9 5/8 to 12 in.	28 to 36 lbs.

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BRITISH WALKIE-TALKIE

(*Continued from page* 130)

operate. To insure proper tap selection, an antenna current indicator is provided. This consists of an rf current transformer whose low impedance primary is connected in series with the antenna. The secondary, electrostatically shielded from the primary to prevent capacitative coupling, is connected to a diode rectifier whose output operates a microammeter. Maximum meter deflection occurs at the tap setting which permits maximum power transfer into a given antenna. The meter reading is a measure of antenna current and provides a very effective means of determining quickly the best tap to use for a given antenna.

A unique circuit was created for the transmitter, to provide a 1 mc crystal oscillator for calibration check of both receiver and transmitter tuning dials. A simplified circuit is shown in Fig. 9. The 1LD5 tube already used as a modulator and antenna current rectifier is alternately used, this time as a crystal oscillator, by connecting a 1 mc crystal betwen plate and control grid through a .0001 blocking condenser. Using an rf choke from plate to the audio choke needed for the modulator, the tube functions as a Pierce oscillator. When the switch shown in Fig. 9 is closed oscillations cease and the tube performs as an audio amplifier. The introduction of the crystal and rf choke has no undesirable effect upon modulator performance.

Crystal calibrator

In operation, the crystal oscillator, being very rich in harmonics, radiates sufficient energy to be picked up on the receiver. Using the cw oscillator of the receiver, the dial calibration is easily checked against the 6th, 7th and 9th harmonics of the crystal. For the transmitter calibration, the master oscillator and calibrator are turned on. Using the receiver as detector (cw switch off), the two oscillators are heterodyned at 6, 7, 8 and 9 mc. The "aerial switch" connects to taps on the tuned tank circuit inductance of the power amplifier tubes. The "Systems" switch marked "CW Phone-Net-Cal" permits the selection of the desired condition of the transmitter. The meter switch, in conjunction with the test meter, provides for rapid checking of the high and low battery voltages, and the emission current of the tubes in the receiver and transmitter.

It also indicates grid current of the power amplifier tubes. With the switch in the position marked

(*Continued on page* 138)

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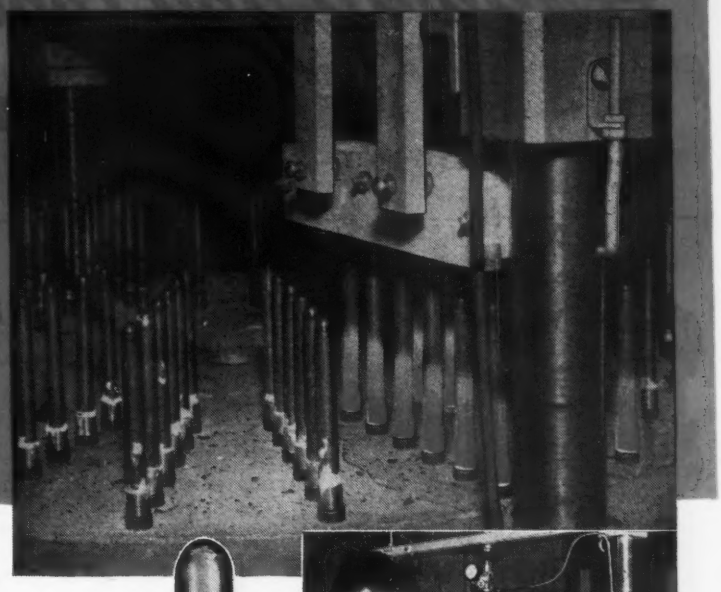

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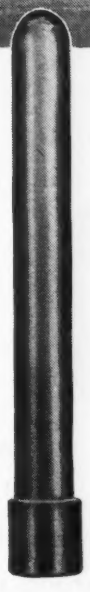
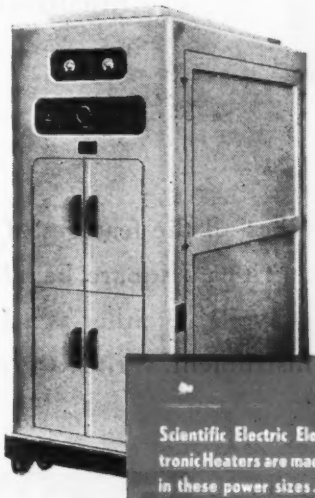


Above: This practical, automatic brazing turntable powered by a 40 KW. Scientific Electric heater speeded up production 700%—cut costs 87% and reduced rejects by 90%.

Left: Close-up of the finished two-piece tube assembly after being brazed by induction heating. Three complete brazing installations have been built for Progressive.



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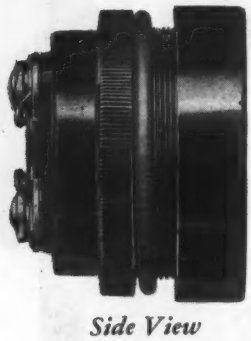


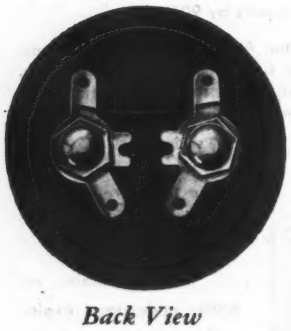
Side View

Front, side or back—inside and out—the 1½" Round Model 120 can do a whale of a job for you on a wide variety of applications.

External pivots provide maximum accuracy in mounting the moving element between the jewel bearings ... prevent rocking of pointer... reduce side friction between jewels and pivots...increase the life of bearing surfaces. Movements are designed to meet forthcoming JAN-I-6 specifications for 1½ inch instruments.

Front View

Built with fine precision, entirely self-contained ...with built-in resistors and shunts, this great little meter is also completely immersion-proof throughout. It has a special locking device for exerting pressure against rubber gaskets on either side of the glass. Watertight sealing includes terminal studs and a gasket back of the flange waterproofs the juncture between the meter and the panel. Installation is easy—a ring mounting eliminates mounting screws. The case is Black Anodized Aluminum.



Back View

Model 112 has all the features of the Model 120 except that it has a square, bakelite case. Like the 120 it is available either as a D.C. or A.C. (rectifier) instrument. Write for latest catalog.

"Inside" View

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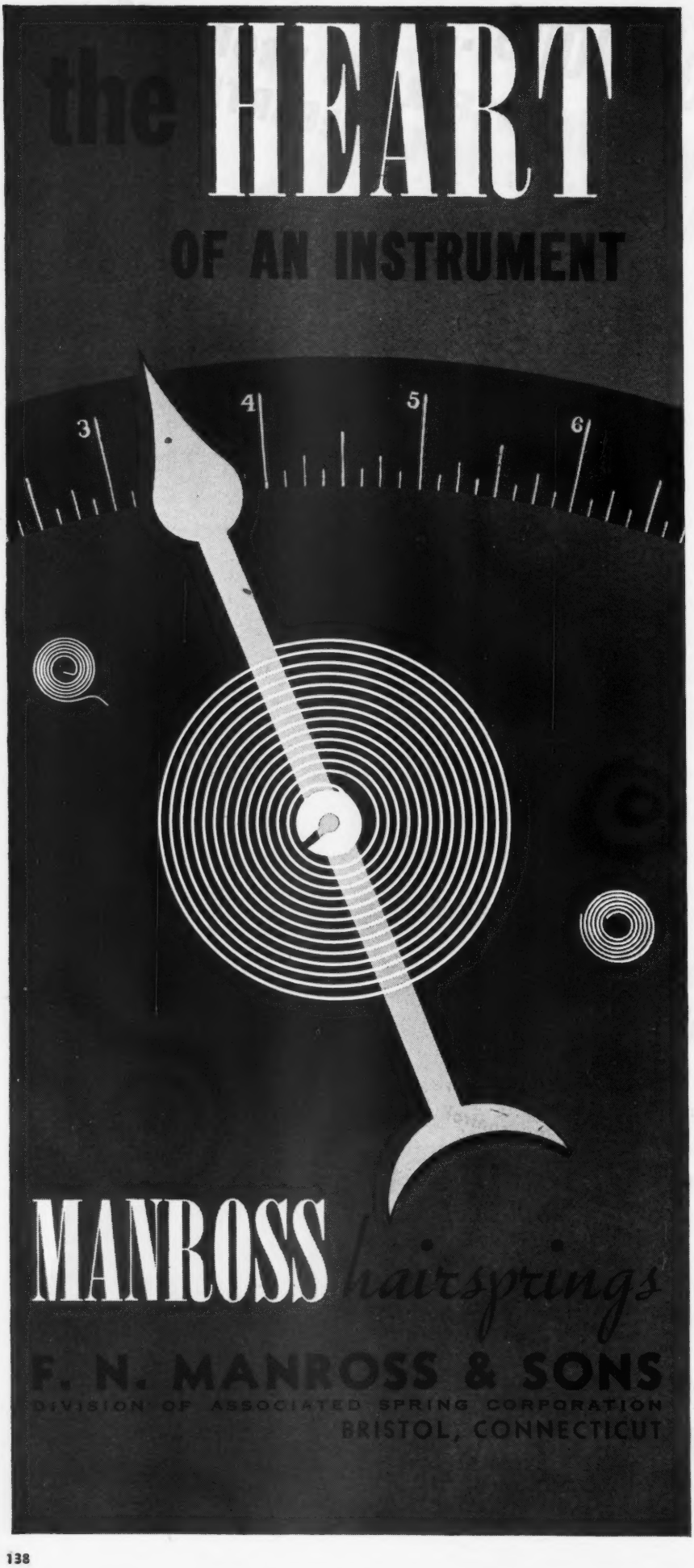


BRITISH WALKIE-TALKIE

(*Continued from page* 134)

"AE" the meter indicates a measure of aerial current. The changeover from "Send" to "Receive" is performed by actuation of the press switch of the microphones or the Send-Receive switch of the cw key. These switches operate the relay which controls the aerial and filament supply. For cw transmission a jack is connected in the high voltage negative return of the sender and the key is connected by means of a plug.

Power for the set may be drawn from dry batteries or hand powered generator. Filament heating is provided by a 3-volt battery. A 162-volt battery, tapped at 12 volts, provides the high and relay voltages. The filament current consumption is 0.32 amp. on Send Phone, 0.25 amp. on Send cw, and 0.15 amp, on Receive. The B battery drain is 20 ma on Send Phone, 50 ma on Send cw, and 8 ma on Receive. Assuming a ratio of transmission to reception time of 1 to 3, about 15 hours of continuous operation of the B48 is possible on one battle battery. With external static battery, greatly increased life is obtained.

Hand generator

The Emerson developed manually-operated hand-cranked generator, with a built-in filter and regulator, is connected to either the B48 or the B18 by plugging the cord into the generator socket. When cranked by one man at 50-70 rpm it supplies all required voltages for transmitting or receiving on either B18 or B48. A toggle switch changes the connections for either unit. The dimensions of the generator are 5½ x 5⅞ x 6¾ in.

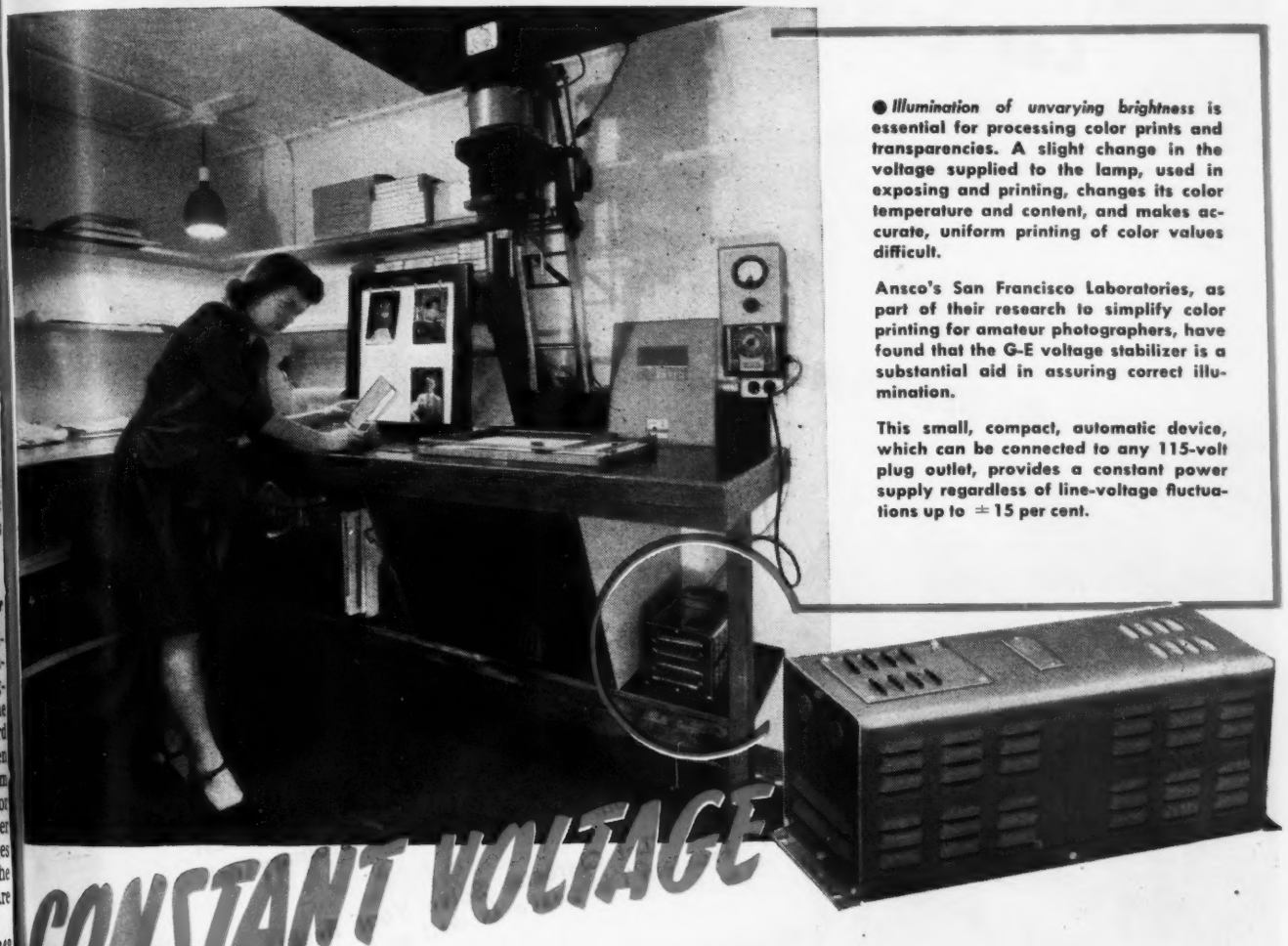
If the toggle switch is on B48 position, the high voltage is 180 volts for B at .106A and the low voltages 3.1 volts at .3A. When the toggle switch is in the B18 position, the high voltage on receiver is 180 volts and on sender 150 volts. The low voltage is 3.1V and the current .3A with bias voltage of 12V. All of these voltages are measured at filter output. The regulator, a vibrating Terrell type, and a very important part of this unit, operates at a frequency of 5 to 7 vibrations per second.

The generator armature is a two commutator type whose shaft is supported on two bearings and is turned through a train of gears (75.4 to 1 ratio). When hand cranked at 60 rpm, the armature rotates at 4,524 rpm.

Because of the heat, humidity and great shipping distances from either England or America to the Burma theatre of operations, bat-

(*Continued on page* 142)

ANSCO Gets Better Color Prints with G-E Voltage Stabilizer



● *Illumination of unvarying brightness* is essential for processing color prints and transparencies. A slight change in the voltage supplied to the lamp, used in exposing and printing, changes its color temperature and content, and makes accurate, uniform printing of color values difficult.

Ansco's San Francisco Laboratories, as part of their research to simplify color printing for amateur photographers, have found that the G-E voltage stabilizer is a substantial aid in assuring correct illumination.

This small, compact, automatic device, which can be connected to any 115-volt plug outlet, provides a constant power supply regardless of line-voltage fluctuations up to ± 15 per cent.

CONSTANT VOLTAGE

may add new accuracy to your precision jobs, too

● On almost every precision job where electricity is used, a closely held voltage supply adds speed or accuracy, or decreases rejects. In addition, it protects delicate instruments, tools and electronic tubes from sudden overvoltages, and increases the reliability and life of such equipment.

If you are a user or manufacturer of such apparatus as radio transmitters, testing equipment, X-ray machines, other electronic devices, motion-picture projectors, and precision photographic equipment, it will pay you to investigate the benefits of G-E voltage stabilizers. They can be used as an accessory to present equipment or built into new, redesigned products to add salability.

These small, compact units are available in ratings from 50 to 5000 va. On circuits where the voltage may vary from 95 to 130 or 190 to 260 volts, they automatically provide a constant 115- or 230-volt output. Because they have no moving parts, the need for maintenance is practically nonexistent. Ask for Bulletin GEA-3634A for complete information. *General Electric Company, Schenectady 5, N. Y.*

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★ Clarostat is ready. This time it's with your peacetime resistance and control problems, as Clarostat's 100% war effort becomes history.

With vastly expanded production facilities for speedy deliveries; with a skilled personnel second to none; with rare experience in meeting the more critical design and production requirements of the war, Clarostat can and is offering you extraordinary collaboration.

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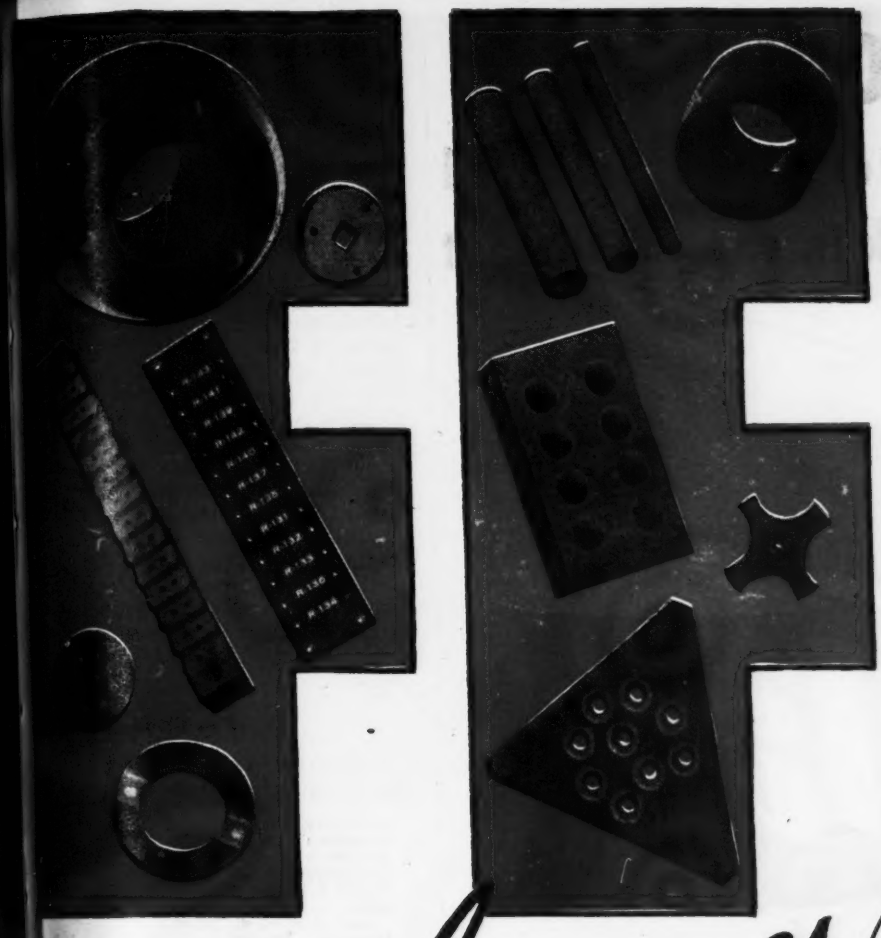

FF-55

deserves P.H.D.

FOR THESE MARKS IN CHEMISTRY AND PHYSICS

This recent graduate of the Formica war-expanded laboratories has passed the following tests and is qualified for employment in many old and new applications.

It is made with melamine resins and glass fibre base and conforms to Navy Grade GMG.

It withstands 440 degrees F for a short period, and 390 degrees continuously.

Its arc resistance reaches a new level—by ASTM test D 495-42 it is rated at 185 seconds.

It is so strong it can take structural stresses when desirable. Test figures: Tensile strength 25,000 P.S.I.; Compressive strength (flatwise) 90,000 P.S.I.; Modulus of Elasticity in bending 3,000,000 P.S.I.; Izod impact, 12 ft. lbs. per inch of notch.

FORMICA

Here is a new combination of desirable properties not previously available in one material. Unlike various materials which possess some of these characteristics, FF-55 can be easily punched and machined. It is superior for rapid fabrication by production methods.

THE FORMICA INSULATION COMPANY, 4647 SPRING GROVE AVENUE, CINCINNATI 32, OHIO

NOW... get an Instrument Rectifier and a Balanced Resistance network in one convenient plug assembly

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The lid's off! Now, Conant can give you this new development that meets the demands for applications that involve the balanced bridge principle in AC operation.

A striking example of Balac's many uses is the conversion of standard Wheatstone bridge instruments to AC. AC accuracy and performance become equal to DC operation on the same instrument. Null indication is never affected by temperature, frequency, wave form or line voltage changes.

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378 Boulevard N. E., Atlanta, Ga.
4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
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50 Yarmouth Rd., Toronto, Canada

BRITISH WALKIE-TALKI

(*Continued from page* 138)

teries were of little use there unt the British were able to manufac ture batteries nearer to the fiel of operation. They, therefore, ha to depend almost entirely on th hand operated generator.

Many of the Emerson Radio en gineering and Procurement staf have made substantial contribu tions to this project. Messrs. A. G Rogers and J. W. Jennings directe the engineering. Messrs. Murra Goldstein, Henry Fogel and Walte Lukas were responsible for the elec trical engineering on receiver transmitter and generator, respec tively. Edward Buechner and Ab Skolnick handled the mechanica engineering. In addition, the splen did and resourceful material pro curement program conducted b H. J. Dostal contributed much t the all-around success of thi project.

Performance dat

Measured performance of th B48 follows:

*Sensitivity Phone	5 microvol
*Sensitivity C.W.	3 microvol
Selectivity X 10	17
Selectivity X 1000	55
Image Rejection Ratio	250 to
AVC	Output change of 10 db for inp change of 40 db
Frequency Stability	.02% for 1 ho warm up period
Signal to Noise	10 to
Dial Calibration	100 Kc interva
*Power Output	25 milliwatts at 10 distortion
Output Impedance	200 and 4000 oh
Fidelity	—3 db from 300 to 2500 cp
**Power Output Phone	0.25 wat
**Power Output C.W.	1.15 wat
Modulation	To 100
Capability	30% distortion at 95 modulation
Fidelity	—3 db from 300 to 2500 cp
Calibrator	Built in crystal oscillator 1 megacycle to check dial calibration.
Frequency Stability	.02% for 5 minu warm up period.
Dial Calibration	50 Kc Interva

*Input carrier modulated 30% at 400 cp Output of 1 milliwatt into resistance load o 200 ohms.

**Into dummy load of series 50 mmfd con denser and 7 ohm resistor.

Resin Plasticizer

One of the most closely held secrets of the war has been lifted in part by consent of the Navy with the news that a new type resinou plasticizer is used to prevent pre mature failure and loss in signa strength of high frequency cable for Navy equipment. Known a Paraplex G-25 and developed by the Resinous Products & Chemica Co., Philadelphia, this product might be described as a "polymeric" plasticizer, the first resinous type plasticizer compatible with poly vinyl chloride, the preferred cable jacketing material, and which com bines the desirable features of ester type plasticizers with the per manence and non-migrating quality of a synthetic resin.

Quiet

Efficient—reliable—above all, *QUIET*—
that's the Ballentine Phonograph Drive.
Basic refinements in design, *precision*
dynamic balance, the most advanced
manufacturing technique and equipment make
the Ballentine Phonograph Motor unequalled
for low background noise or rumble.
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PROTECTS TELETYPE* EQUIPMENT FROM MOISTURE DAMAGE • • •

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A few small cotton bags containing this ideal drying agent are enclosed in the box or carton with the equipment. The phenomenal power of Jay Cee Silica Gel to absorb the atmospheric moisture within the container prevents rust or corrosion in transit. Jay Cee Silica Gel is also used in packages of foods, fabrics, chemicals, and other products. Moreover, it has wide application in the air conditioning, refrigeration, and chemical industries. Jay Cee Silica Gel is clear white; passes a rigid section test, meets exacting Government specifications; is strictly a quality product.

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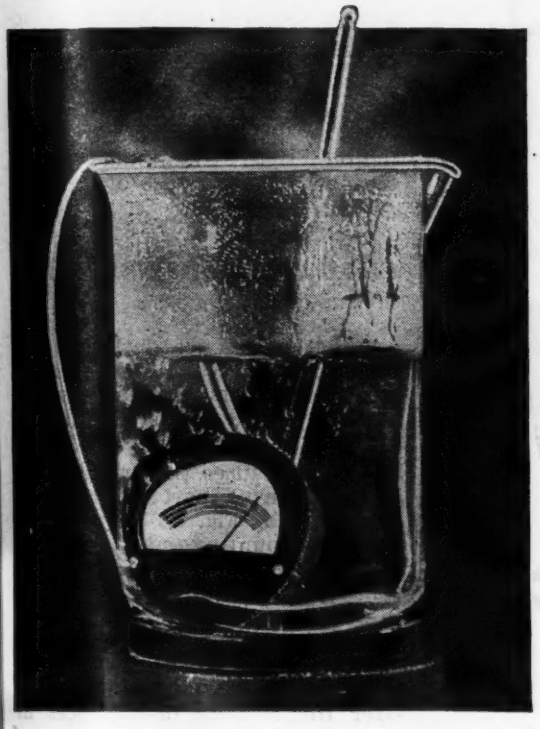

We weren't satisfied to test our hermetically sealed instruments for temperature, humidity and salt spray individually — we went whole hog and combined the three conditions in a beaker of boiling brine. This test, which really exacts more from an instrument than is normally necessary, was conducted for two weeks without failure or permanent error in excess of 1%. The maximum zero shift was .75%, the current sensitivity plus .5% — and the instrument showed no moisture penetration and no leaks as was evidenced by further production vacuum checking.

What may be "unfair" in a test of Marion hermetically sealed instruments is only fair to their users. Whether you're a manufacturer or a consumer, our tests serve to prove the quality and dependability of our instruments. They are an assurance that when these "hermetics" are installed in any equipment, and used in any part of the world, their trouble-free performance will be sustained. Remember — Marion glass — to — metal hermetically sealed instruments are positively interchangeable, and cost no more than standard conventional types. Write for our 12-page brochure.

Marion Glass-to-Metal Truly Hermetically Sealed 2½" and 3½" Electrical Indicating Instruments

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MANCHESTER, NEW HAMPSHIRE

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TYPICAL!—These three units comprising mixer and master output switching assemblies for a critical application are typical of B & W facilities for handling custom-built engineering and production assignments.

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In addition to its complete, well-known lines of Air Inductor Coils and Heavy Duty Variable Condensers, B & W offers a wealth of specialized facilities for the engineering, design and production of custom-built electronic equipment. Among units recently produced are special transmitters, test equipment, tuning units, high—and ultra-high frequency assemblies, high-voltage equipment and many more. What do you need—designed and constructed throughout to match your application *exactly?*

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Thermoplastic Insulator

Plastiform, a new thermoplastic material which can be used in making electrical and other equipment that does not have to withstand high operating temperatures, has been developed by L. C. Wilson, chief engineer for Duorite Plastic Industries at Culver City, Cal. A dielectric, it is 100 per cent reclaimable without additives and impervious to both acids and alkalies. It can be formed by casting in molds or by working with an ordinary soldering iron.

High-frequency heating has been found to be the most economical and efficient process for mass-producing Conolon airplane parts, according to a recent report by Dr. G. G. Havens of the National Research and Mfg. Co. at National City, Cal. Conolon is a new low-pressure plastic laminate, which is lighter than aluminum yet as strong as many types of steel.

CRYSTAL DIMENSIONING

(*Continued from page* 97)

occur at most once during a temperature run, giving, in the absence of other disturbing phenomena, an activity curve such as (a) in Fig. 3.

Wetness causes the crystal to be inactive during part or all of the curve, cf (b) Fig. 3. Uneven pressure in mounting may damp the curve erratically, cf (c) Fig. 3.

Frequently, even when all of these causes of failure have been eliminated, curve irregularity still persists. The accompanying diagram, Fig. 4, is typical. Let us consider the activity disturbances in the order in which they occur from left to right. The activity disturbance (1) has its counterpart in the frequency disturbance approximately under it. When this frequency is repeated we note that once again there is a marked irregularity in the upper curve: 4. A similar relation exists between disturbances 2 and 3. The result is a saw-tooth effect in the activity curve with irregularities paired about the peak of frequency. Certain frequencies thus reveal themselves as unfavorable to the activity of the crystal. At these frequencies conflicting modes contend for control of the crystal and it is unable to give full response to either.

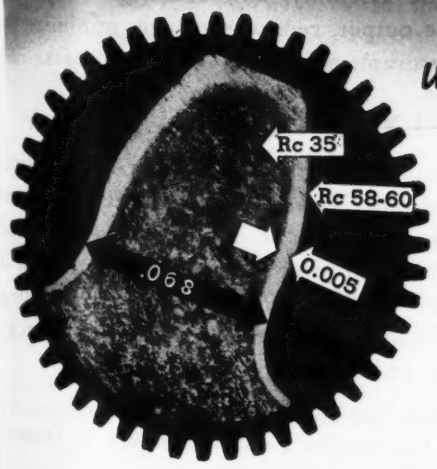
A few instructive crystal records will serve to emphasize the relevance of the crystal dimensions to all this: (1) In Fig. 5 nothing has been changed between the runs which produced curves 1 and 2, except the height of the air-gap which in neither case was such as to produce air-gap resonance. The

(*Continued on page* 150)

They're All Talking About It!

A New Thin Case Contour Hardening Job . . .

with MEGATHERM*



Thin case contour hardening of gear teeth with controlled depth of hardness has been made possible by the use of MEGATHERM induction heat.

The hardened surface completely follows the tooth and root contour of the gear with the core still in its original state, as shown plainly by this microphotograph. This 0.005 case was applied to gears of 24 D.P. —51 teeth—2.125 P.D.—2.208 O.D. and S.A.E. 4140 steel in 1/4 of 1 second with a 25 KW MEGATHERM—5 megacycle energy doing the job.

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with the personally-fitted lighting of

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Whether for eyes old or young, sound or defective, Dazor *Floating* Lamps make seeing easier on all jobs requiring concentrated and prolonged vision: precision machine work, inspection, fine assembly, and drafting. They help increase output, reduce spoilage, minimize fatigue, promote safety and increase profits.

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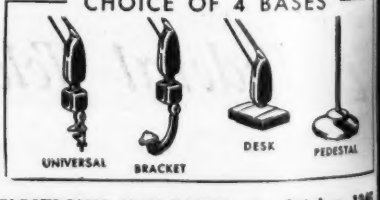
For complete information, experienced application assistance and a practical on-the-job demonstration, phone one of the Dazor-appointed distributors in your locality. Their names, if unknown to you, can be secured by writing to the Dazor Manufacturing Co., 4483 Duncan Ave., St. Louis 10, Mo.

IN CANADA address all inquiries to Amalgamated Electric Corporation Limited, Toronto 6, Ontario.

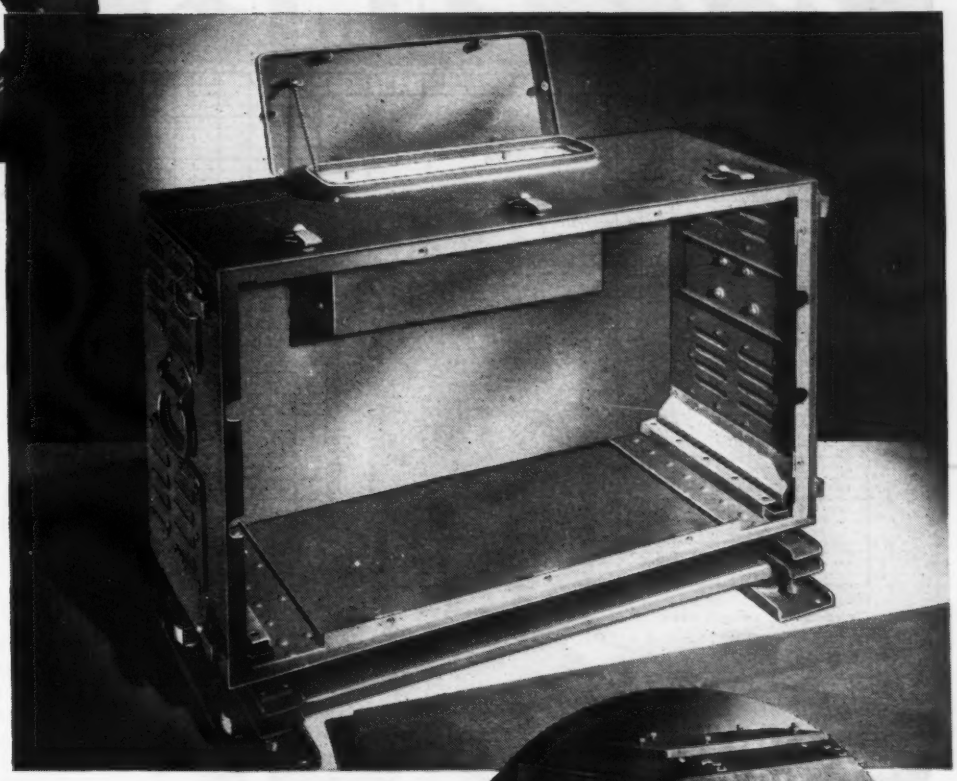


DAZOR *Floating* LAMPS

FLUORESCENT *and* INCANDESCENT

distinguished cabinet member

on a secret mission . . .



The actual use of this Karp-constructed cabinet assembly for electronic apparatus is a military secret.

We can, however, reveal the superior details of the all-welded aluminum construction. It is splash-proof, insect-proof—and at the same time ventilated. The assembly also includes a shock mount. Suspension slides permit the electronic apparatus to move in and out like a drawer.

If you require special-built housings, racks, panels, chassis or enclosures for electrical equipment, get the benefit of our 20 years of specialized experience in this field. Our hundreds of skilled craftsmen will save your time. Our complete facilities and numerous stock dies will save you money.

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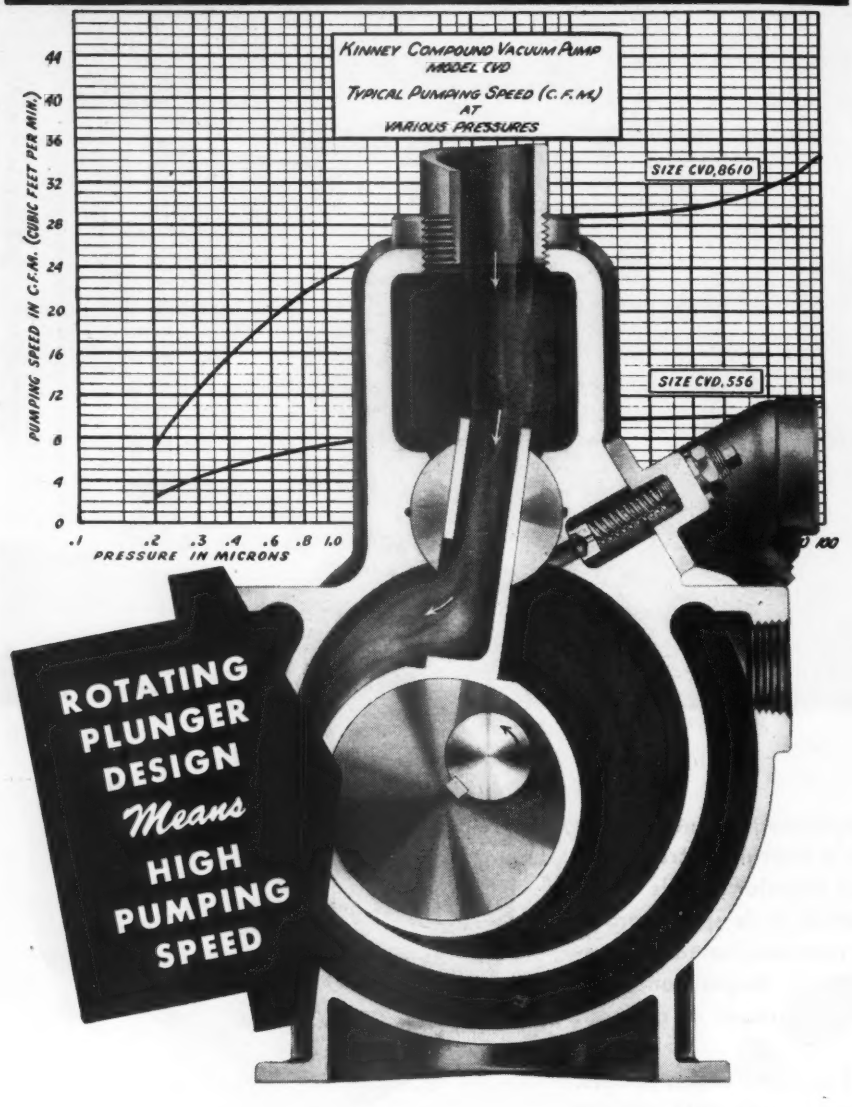
KINNEY High Vacuum PUMPS



The design of Kinney High Vacuum Pumps has been proved by years of actual performance; today in over 10,000 installations, Kinney Pumps are producing low absolute pressures rapidly and dependably.

The rotating plungers of the long-lived Kinney Pump have no contact with the cylinder walls, all clearances being perfectly sealed and lubricated with oil. Kinney Single Stage Pumps maintain low absolute pressures to 10 microns; Compound Pumps to 0.5 micron or better. Write for information.

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We also manufacture Vacuum Tight Valves, Liquid Pumps, Clutches and Bituminous Distributors

CRYSTAL DIMENSIONING

(*Continued from page* 146)

effect of the change in air-gap is to change the frequency by a small amount without altering the crystal physically. We note that the frequency disturbance at the peak of curve 1 has its counterpart in an activity disturbance above, and that similar disturbances take place in curves 2 when the same frequency is passed.

We conclude that bad behaviour at this frequency is a characteristic of the crystal and its unchanged dimensions. (2) cf Fig. 6. This time electrodes and mounting are unchanged and one dimension is altered progressively. Here the activity disturbances change frequency with each dimension—change and vanish or become negligible for certain dimensions. We conclude that saw-tooth activity irregularity may be corrected by dimension shift.

Importance of stability

It will be noted in each instance that it is the presence of irregularity rather than the magnitude of the irregularity to which I give importance. This is because, being symptomatic of instability, these irregularities, though they appear at the same frequencies, will not necessarily reproduce themselves as to magnitude, even for the same crystal under temperature runs which as far as can be verified are identical. On the other hand, stability does reproduce itself and a relatively smooth activity curve can be expected to repeat itself very closely.

Furthermore, if we simultaneously examine crystals cut within close tolerances as to angle and dimensions, mounted alike, and brought to within close tolerance of the same frequency at room temperature, we note that all their instabilities occur within close tolerance of the same temperatures, or that they are all stable throughout the temperature run for certain dimensions.

Thus we may use the data obtained from relatively few crystals to ascertain safe dimensions for other crystals of the same frequency.

Temperature exploration

Since temperature-runs take time, and since available time is finite, it is obviously desirable to cut down the number of temperature runs involved in discovering favorable dimensions. If in any way we can ascertain that a pair of initial dimensions is near to those which are favorable to a given frequency, then by "pushing" the dimensions

(*Continued on page* 154)

Here's the very heart of your post-war product!

When your new product gets into the consumer's hands, the battery that powers it can spell the difference between consumer satisfaction and disappointment. Ray-O-Vac Batteries are designed and built to deliver plus performance—extra capacity and dependability at lowest possible cost to the user. You take no chances when you specify Ray-O-Vac Batteries. Our engineers are at your service now.

For Dependable Power, Use

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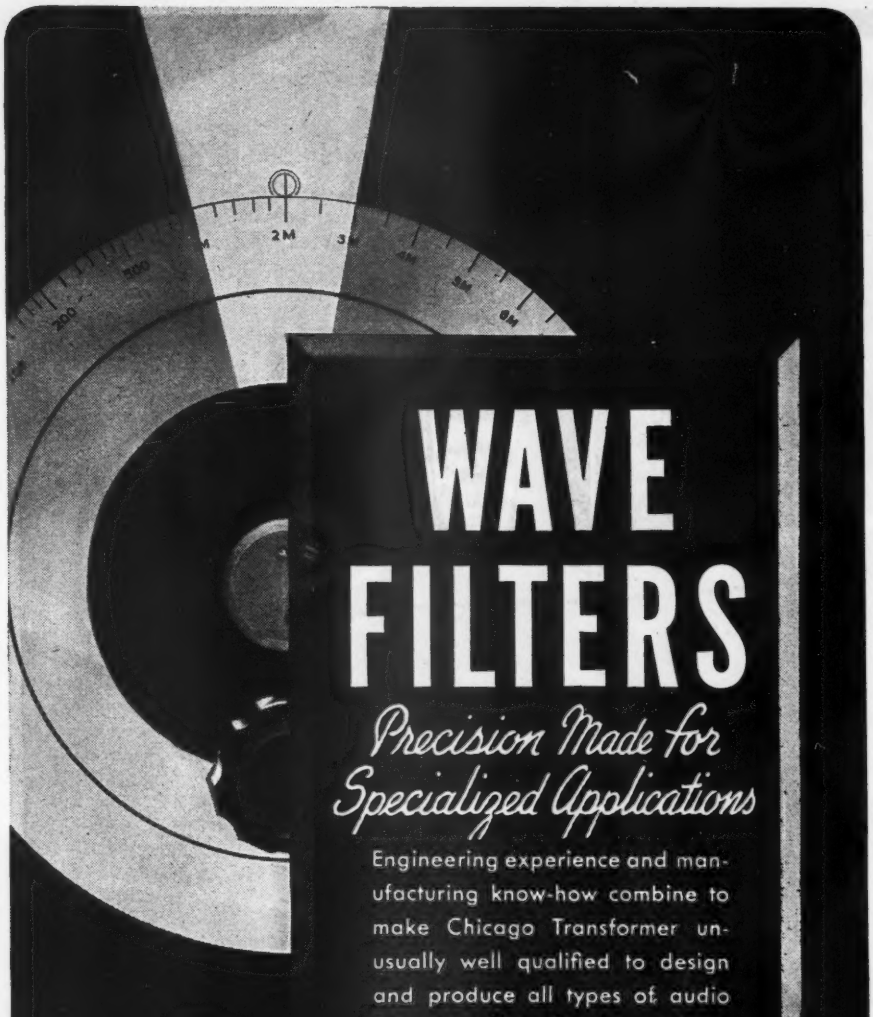

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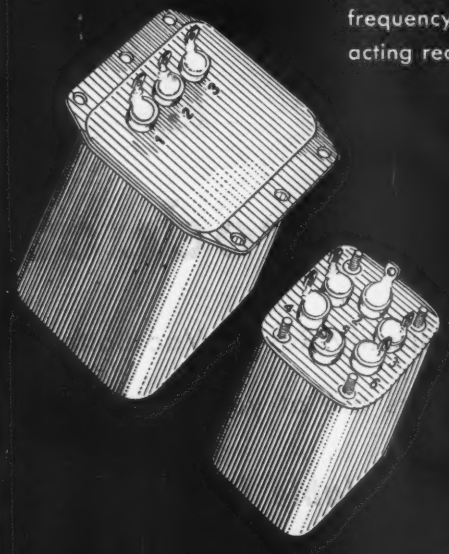
Precision Made for Specialized Applications

Engineering experience and manufacturing know-how combine to make Chicago Transformer unusually well qualified to design and produce all types of audio frequency filters for the most exacting requirements.



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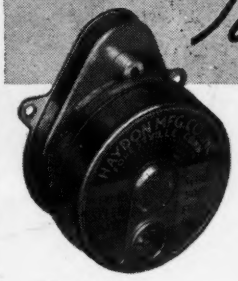

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- Efficient—less added resistance
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- Lightweight, compact
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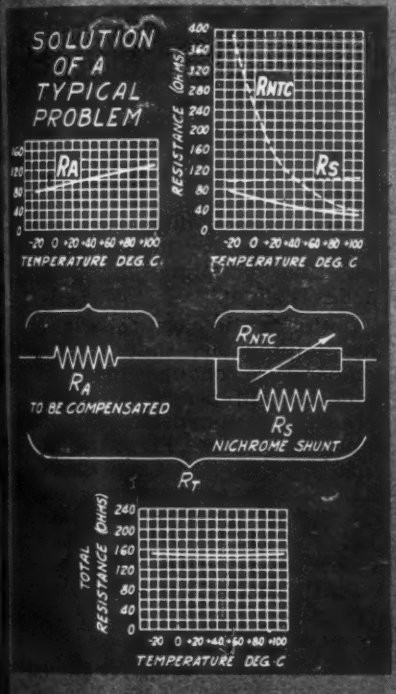

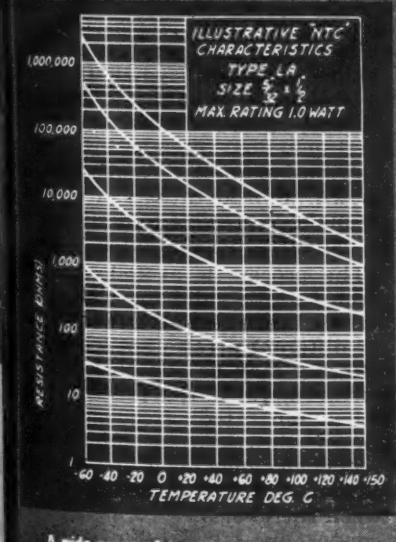

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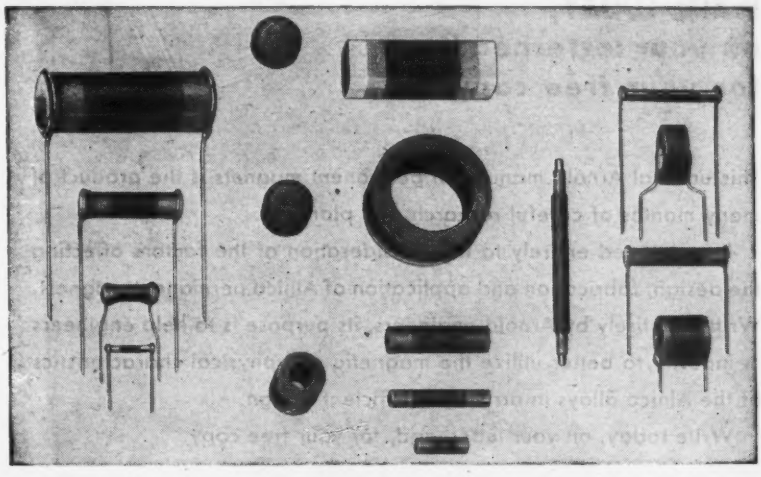

Keystone "NTC" units are thermal resistors of special composition (not carbon), developed and manufactured by Keystone, and extensively used for temperature compensation, temperature measurement and control, time delay and other applications.

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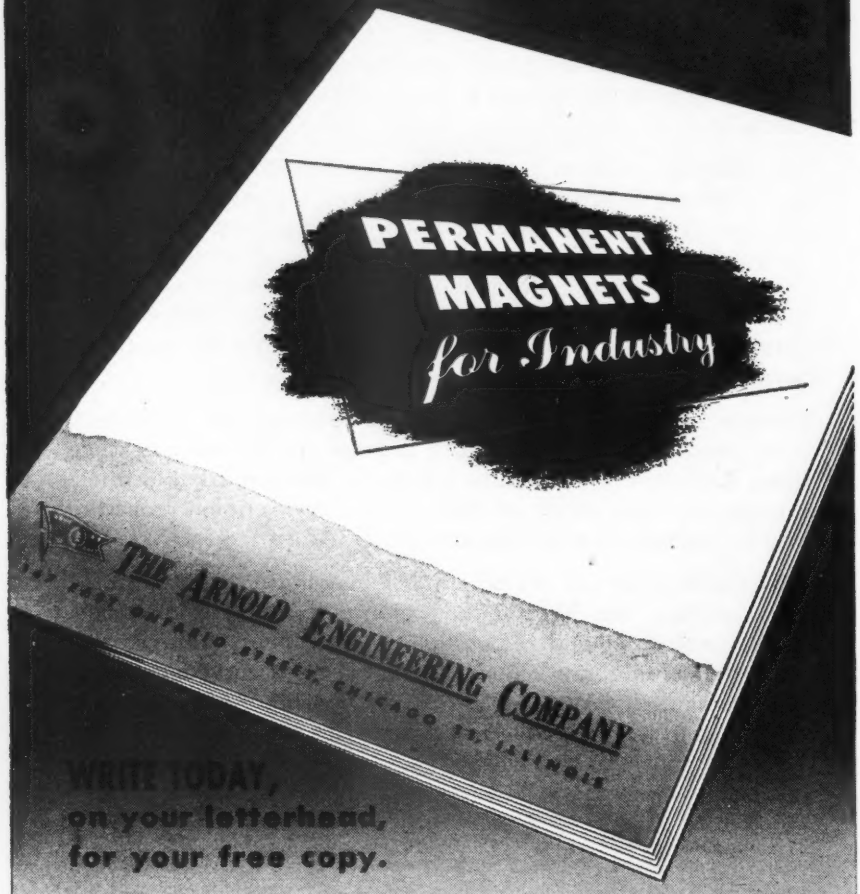

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Specialists in the Manufacture of ALNICO PERMANENT MAGNETS

CRYSTAL DIMENSIONING

(*Continued from page* 150)

about these as a mean we may locate correct dimensions in relatively few runs. One method of obtaining such a point of departure is by the calculation of uncoupled frequencies indicated above. Another, which is purely empirical, follows.

We take a group of crystals of the same arbitrary face dimensions, cut within close angle tolerance and finished to the same frequency at room temperature. Then we progressively alter the same dimensions on these crystals, maintaining fixed temperature, and record frequency change and activity at each step. The accompanying pair of graphs (Fig. 7) is typical of those obtained. It will be observed that in those dimension regions where the frequency curve is smoothest and most nearly approximates the horizontal, activity is highest and most unvarying. From this we tentatively conclude that the crystal in this range of dimensions is relatively insensitive to its contours—i.e., that coupling to unwanted modes is slight.

If this is the case, then it is also not improbable that even with temperature change this lack of coupling will persist for some intermediate dimension - ratio. The explorations of Fig. 7 indicate 1.555 . . . 1.150 as a likely dimension region. The temperature runs of Fig. 6 were made on this assumption and the excellent ratio 1.153 thus arrived at. This ratio was consistently verified for a set of similar crystals.

Key frequencies

This is a technic that is applicable to any frequency. Fortunately the vast amount of painstaking work involved in frequency by frequency exploration and verification may be shortened once corresponding dimensions for a distribution of key frequencies are known. Considerations of continuity make it possible to derive curves on which interpolation is possible.

The process is as follows: If a given ratio is valid for a given frequency, then for a frequency too far different a ratio not too greatly differing may be expected to work. Furthermore, if the ratios for two well - separated frequencies are known, the ratio for intermediate frequencies may, as a first approximation, be taken to lie linearly between the two.

This will not prove to be accurately the case, but if crystals are made up near this ratio, and their ratio varied, the correct ratio may then be verified in terms of activity and frequency performance. As

(*Continued on page* 158)

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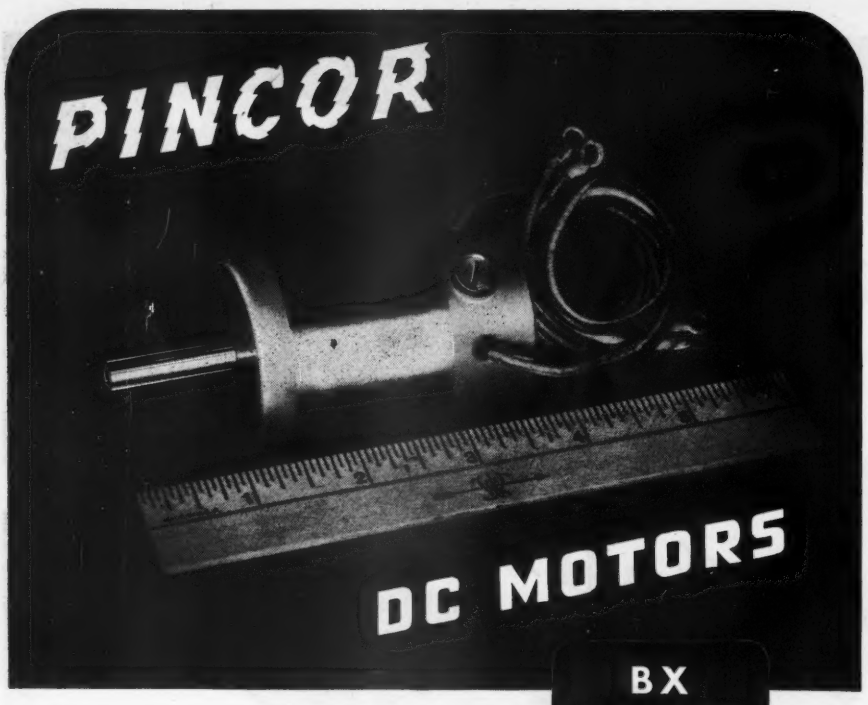

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CRYSTAL DIMENSIONING

(*Continued from page* 154)

verified ratios accumulate, it appears that they lie not on a straight line with respect to frequency but may be very closely fitted with an hyperbola, or inverse ratio curve. With this knowledge and three well-separated, verified frequency-ratio points, we may derive an equation from which the ratio for all other points may be accurately ascertained—a fact which is easily verified experimentally.

It is to be remembered that the curve thus derived will not be unique. Further exploration will discover other curves lying, roughly, parallel to it.

But when this charting has been completed the manufacturer will be in a position to know that a crystal of a given cut and frequency, accurately cut, lapped, dimensioned and finished, and mounted, will differ by a minimum amount from any other similarly processed.

OWI 200 KW UNITS

(*Continued from page* 103)

loops. The schematic diagram of Fig. 5 shows the details of the equipment and indicates the tube types used.

The line amplifier equipment in the control room feeds audio frequency energy to the low power unit at a level of about 10 vu. From there it is passed to the intermediate amplifier, and thence to the modulator stage, which is designed to use either four or six Federal F-125A tubes operating Class AB, that is, without grid current. The four-tube complement is used when modulating two 50 kw power amplifiers, instead of the 200 kw amplifier. As will be noted in the circuit diagram, two Federal F-872 mercury-vapor rectifier tubes are connected across the grid circuit of the F-125A modulator stage for protection again current surges due to possible grid-plate flash-over.

Overall audio frequency response of the audio amplifier-modulator equipment is within 0.5 db of the 1,000-cycle level from 30 cycles to 10,000 cycles. Harmonic distortion is less than 5 per cent from 50 to 7,500 cycles at 95 per cent modulation.

The main rectifier has twelve Federal F-857A mercury-vapor rectifier tubes, arranged in banks of six, in a three-phase, full-wave rectifier circuit to supply 12,000 volts for the 200 kilowatt power amplifier. A seventh F-857A tube is included in a stand-by position with each group of six rectifier

(*Continued on page* 162)

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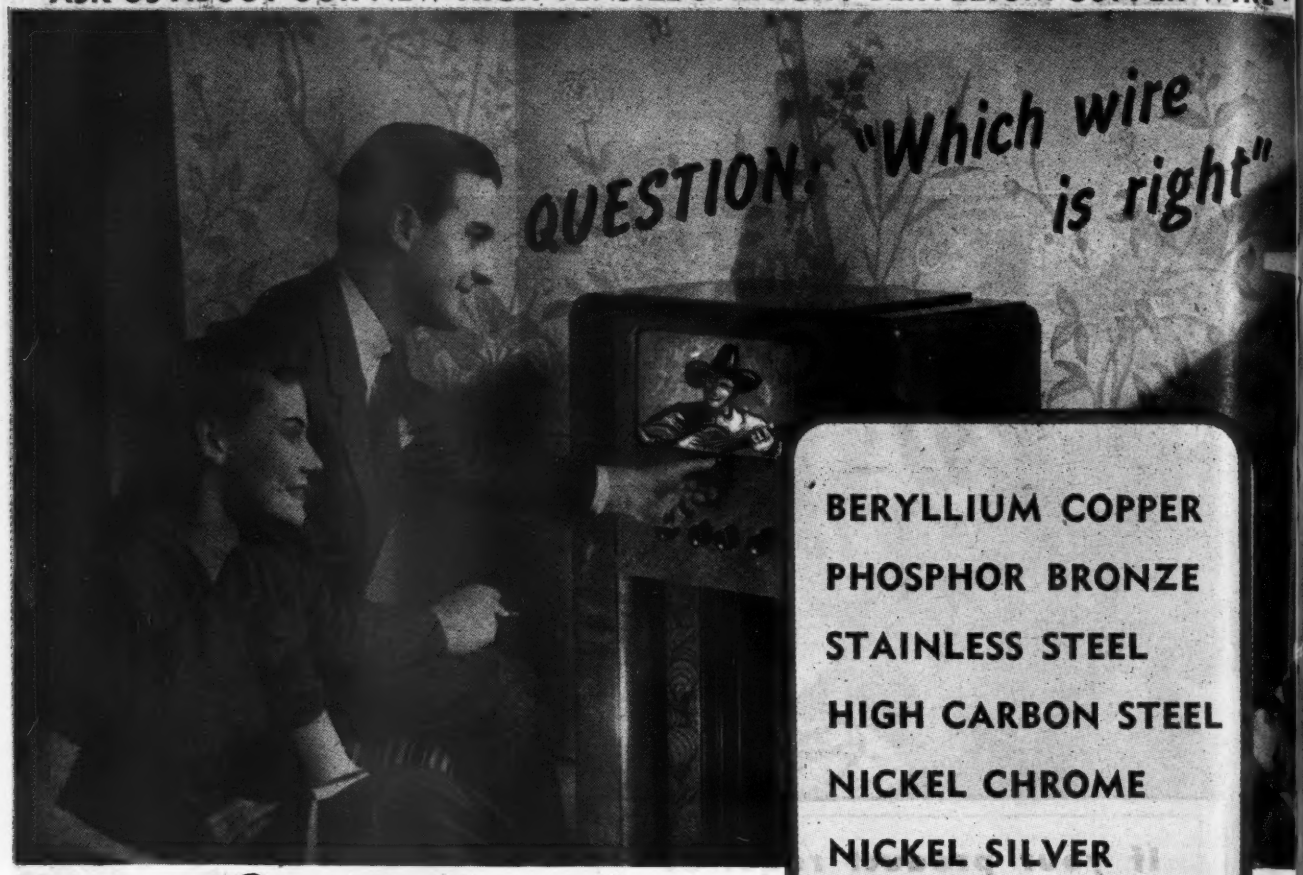

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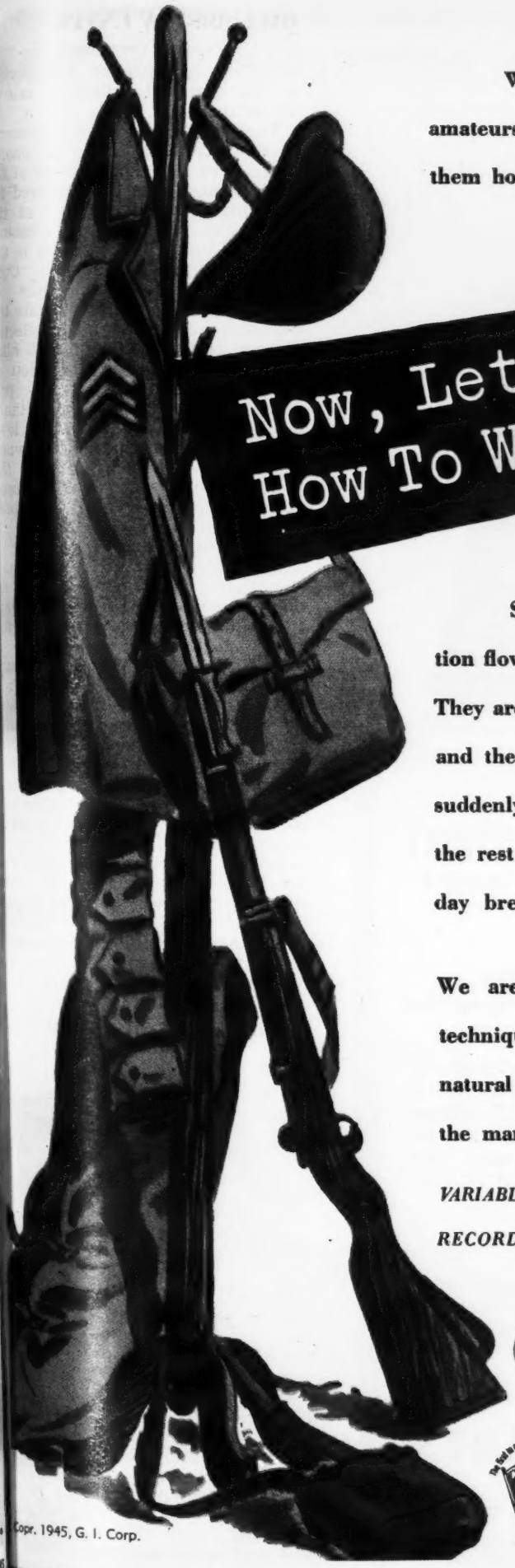

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OWI 200-KW UNITS

(Continued from page 158)

tubes, to be switched into service in the event of failure of one of the active tubes.

The transformer bank is connected in delta-delta to permit operation at reduced power if one of the transformers must be removed for servicing. Output voltage of the rectifier is controlled by the motor-operated induction regulator in the 2,300 volt primary supply. Controlled either automatically or manually, this regulator holds the rectifier output to any selected voltage between 8.0 and 12.5 kilovolts. In automatic operation of the regulator, opening of the primary circuit breaker instantaneously sets the regulator at its lowest operating position, so that when the circuit breaker is closed the rectifier will start at a reduced voltage and slowly reach any predetermined value.

The international broadcast transmitters at both the Dixon and the Delano stations are now in operation about 20 hours per day. In the design of the equipment for these stations ample margin of safety has been stressed to assure uniformly high performance free from interruptions due to breakdown of components. At the same time, this has been accomplished without any sacrifice in flexibility, the motor-operated tuning controls in the 200 kw power amplifier being particularly useful in making rapid changes of frequency. Though departing in several important respects from the design of more conventional lower powered amplifiers, the basic design of the 200 kw power amplifier has proved completely dependable, entirely practical and highly efficient.

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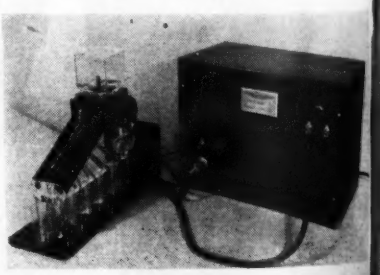

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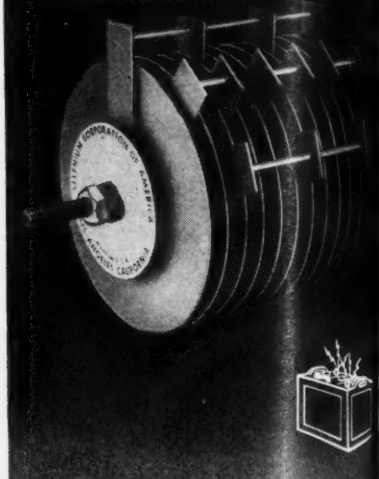

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WIDE READING

(*Continued from page* 113)

galvanometer is recorded photographically, and the resulting records have the appearance of a modulated carrier wave.

Accessory equipment

Two similar electronically regulated power supplies are provided; the heater supply is diagrammatically illustrated in figure 2. Upon an increase in heater voltage, the grid potential of tube 6SF5 2 increases, that of the right-hand section of the tube 6SC7 2 decreases, while that of the left-hand section increases, causing the plate potential of the left-hand section to decrease cutting off current through the 5 6L6 tubes connected in parallel.

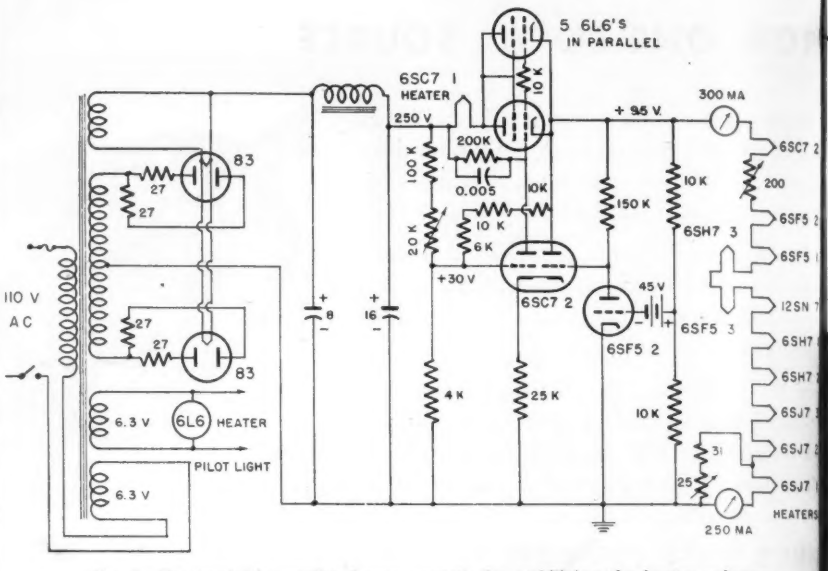

Fig. 2. Electronically regulated power supply for stabilizing the heater voltages

It is important that the operator be able to observe the output of the thermocouple amplifier while obtaining a spectrum. Provision of a portable output meter satisfies this requirement. A two tube amplifier and vacuum tube voltmeter combination connected to the plate of the 6SJ7 1 tube is used for the visual indicator.

Test methods are described and details of the operation and performance of the circuit given; the noise behavior is illustrated by oscillograms taken with different inputs.

Degassing of Metal Alloys

W. Esmarcht, T. Rommel and K. Benther (W. V. Siemens Werke, Werkstoff Sonderhefte, Berlin, 1940, pp. 78-87; reported in Electronic Engineering, London, July, 1945).

The passage of an ultrasonic wave through a liquid is accompanied by the liberation of gas bubbles, and therefore these waves can be used for degassing metallic melts. The method described proposes the generation of waves directly inside the molten metal.

In the electric furnace discussed (operating frequency of the order of 10 kc), the heat production is caused by the formation of eddy currents in the charge. These eddy currents, in addition, cause a rotary motion of the molten metal which favors the absorption of air by the molten material and counteracts to some extent the degassing effect of the rise in temperature.

By superimposing a constant magnetic field on the high-frequency field of the furnace, mechanical vibrations are induced in the melt, the force at each point being proportional to the product of the local current density and the field strength and acting radially to the coil axis. By a suitable choice of bath dimensions, resonance effects can be produced which increase the intensity of the vibrations. We thus have a method of generating high-frequency waves within the melt.

In the experiments a 10,000 cycle generator delivered a current of the order of 100 amperes to the furnace coil. The total energy consumption amounted to about 15 kw of which 10 kw were supplied by the high frequency generator. With a specially designed heating coil the energy consumption for the steady magnetic field could have been reduced very considerably. The experiments were carried out with 8 to 10 kilograms of melts of pure aluminum and aluminum-magnesium alloys, the temperature was kept constant at 700 deg. C. Samples were drawn off every

(*Continued on page* 170)

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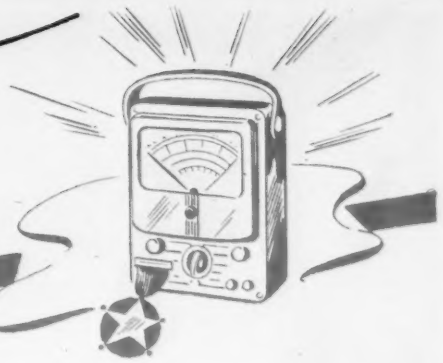

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This is not our own appraisal of the Simpson 260. We knew, before the war, that it was a fine instrument but, frankly, we didn't know *how* good it was until war wrote the record. Now the story of the 260 is written into the records of such wartime industrial developments as that of synthetic rubber, and into the vast and secret research and servicing of radar.

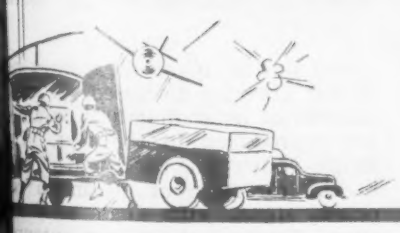
Originally designed as a radio serviceman's test unit, the Simpson 260, because of its sensitivity and wide range was found adaptable to general service duties in the entire electronics and electrical fields. Not a warborn instrument, the 260 was given thousands of essential war jobs in the production and servicing of communications equipment. It made a vital contribution to the success of tactical operations.

Over 300 government agencies and university laboratories of the United States and Canada procured every one of these test instruments Simpson could deliver on an expanded war production schedule. They were turned out by the thousands. Every branch of the armed services—Army, Navy, Marines, Coast Guard—carried them to the far ends of the earth. They were compelled to perform under conditions often so arduous that testimonials of amazement at their ability to function at all became commonplace as the record grew.

Chosen on its merits, the Simpson 260 became uniquely *the* test instrument of the war.

AVAILABLE NOW TO YOU

Now the Model 260, always the preferred instrument of radio servicemen, is available again to a widened field of peacetime services. We ask you to remember its record as an example of the quality and advanced engineering that goes into all Simpson instruments, as evidence that other new Simpson developments are well worth waiting for. They will be released as soon as Simpson standards for their manufacture are satisfied. They will continue the leadership that has given Simpson a world-wide reputation for "instruments that *stay* accurate" with ideas that *stay* ahead.



SIMPSON ELECTRIC COMPANY
5200-5218 W. KINZIE ST., CHICAGO 44, ILL.

Simpson

INSTRUMENTS THAT STAY ACCURATE

SIMPSON 260, HIGH SENSITIVITY SET TESTER FOR TELEVISION AND RADIO SERVICING
Ranges to 5000 Volts—Both A.C. and D. C. 20,000 Ohms per Volt D.C.—1000 Ohms per Volt A.C.

At 20,000 ohms per volt, this instrument is far more sensitive than any other instrument even approaching its price and quality. The practically negligible current consumption assures remarkably accurate full scale voltage readings. Current readings as low as 1 microampere and up to 500 milliamperes are available.

Resistance readings are equally dependable. Tests up to 10 megohms and as low as ½ ohm can be made. With this super sensitive instrument you can measure automatic frequency control diode balancing circuits, grid currents of oscillator tubes and power tube, bias of power detectors, automatic volume control diode currents, rectified radio frequency current, high-mu triode plate voltage and a wide range of unusual conditions which cannot be checked by ordinary servicing instruments. Ranges of Model 260 are shown below.

Price, complete with test leads.....$33.25
Carrying case 4.25

ASK YOUR JOBBER

Volts D.C. (At 20,000 ohms per volt)	Volts A.C. (At 1,000 ohms per volt)	Output	Milliamperes D.C.	Microamperes	Ohms	
2.5	2.5	2.5 V.	10	100	0-1000	(12 ohms center)
10	10	10 V.	100		0-100,000	(1200 ohms center)
50	50	50 V.	500		0-10 Megohms	(120,000 ohms center)
250	250	250 V.				
1000	1000	1000 V.				
5000	5000	5000 V.				

(5 Decibel ranges: —10 to +52 DB)

WATCH FOR NEW SIMPSON DEVELOPMENTS. THEY WILL BE WORTH WAITING FOR!

WORLD'S FASTEST PLANE *uses* ANDREW COAXIAL CABLES!

Lockheed's sensational new jet-propelled super fighter, the P-80 "Shooting Star," is the world's fastest and highest flying plane.

★ It is highly significant that Andrew coaxial cables were chosen for the vital radio and radar equipment installed in the P-80. They were selected because they are much more resistant than ordinary solid dielectric cables to the high temperature encountered in the tail of the plane.

Andrew Co. is a pioneer manufacturer of antenna tuning and phasing equipment, including a complete line of ceramic insulated coaxial cables and all necessary accessories. *Write for catalog.*

ANDREW

ANDREW CO.

363 EAST 75th STREET, CHICAGO 19, ILLINOIS

WIDE READING

(*Continued from page* 166)

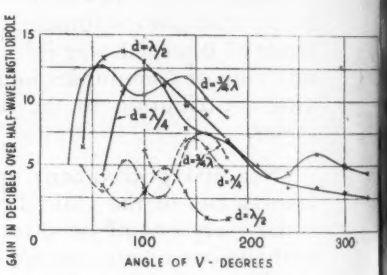
minutes and the gas content determined by the vacuum method.

It appears that alloys containing even relatively large percentages of Mg can be completely degassed by this method in 30 to 60 minutes, provided the surface of the melt is protected by a fused salt layer and that dry air or nitrogen is directed onto the surface during the treatment. The salt used had the following composition: KCl 40 per cent, NaCl 30 per cent, NaCi 30 per cent, $CaCO_3$ 15 per cent, NaF 15 per cent.

Polar Diagrams for Antennas

J. S. McPetrie, L. H. Ford and J. A. Saxton (Wireless Engineer, London, June, 1945)

Experiments are reported on the directional properties of a half-wavelength receiving antenna associated with a V-shaped wire-netting reflector. Polar diagrams were measured with 50 cm waves for various angles of the V between 80 deg. and 330 deg. and distances of the antenna of quarter, half and three-quarter wavelengths from the apex of the reflector. The antenna was placed either parallel or perpendicular to the apex of the reflector; measurements with the antenna in the plane of a sheet reflector are also discussed. A great number of polar diagrams obtained are reproduced in the text. The figure shows the variation of gain in the direction of maximum received signal with angle of V for three distances d between antenna and apex of V. The full-lines were obtained with the antenna parallel to the apex of the V, the dotted lines with the antenna at right angle to the apex of the V.



Directional characteristics of half-wave antenna associated with V-shaped reflector

The following results are stated. The backward radiation decreases as the angle of the V is decreased. The backward radiation increases with increase in antenna-reflector distance. If the antenna is parallel to the apex and for angles of V in the neighborhood of 80 deg. to 100 deg., there is no appreciable change in the polar diagram or gain with

(*Continued on page* 174)

SEND FOR THIS

RESISTOR DATA

For the convenience of designers of products requiring resistors, Ward Leonard offers this new Resistor Handbook. It describes in detail the full line of wire-wound resistors giving complete information on mountings, enclosures, terminals and resistance values. Write for your copy today.

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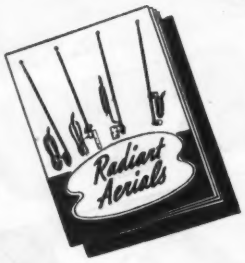

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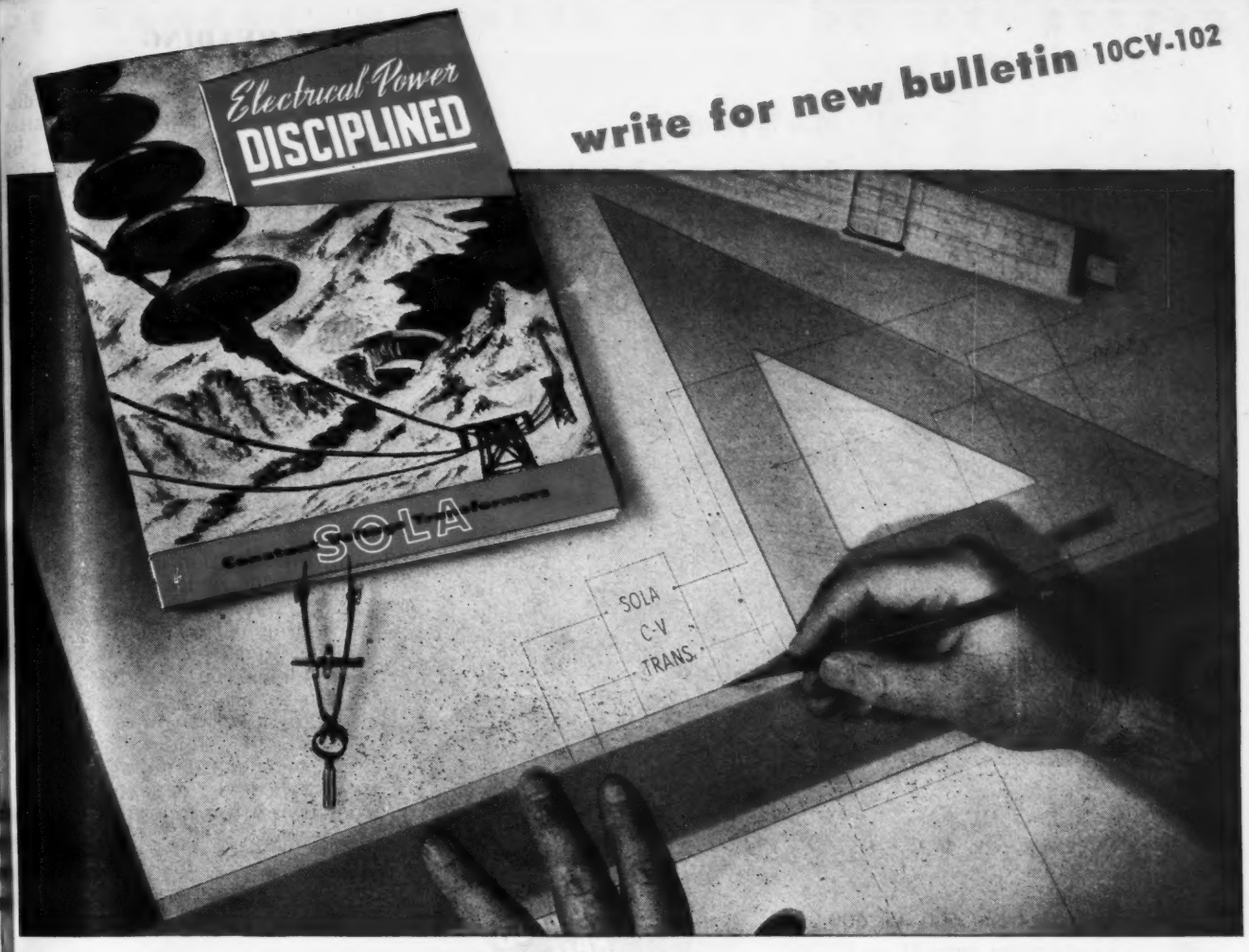


LABORATORY VOLTAGES accompany your equipment into the field with built-in CONSTANT VOLTAGE

On the drafting boards of hundreds of sales-minded design engineers, product insurance is being written into the specifications of new electronic and electrically operated equipment.

A critical analysis of sales department records of past performance usually discloses that the most frequent cause of equipment failure or sub-standard performance is the one most often overlooked — field voltages that do not correspond to the rated voltage at which the equipment is designed to operate.

Today sales-minded design engineers make certain that carefully controlled laboratory voltages, on which the operation of their equipment is predicated, go with it into the field, by writing "SOLA Constant Voltage Transformers" into their design specifications. In many cases the inclusion of the "CV" transformer is accomplished at an actual saving in cost over standard equipment design.

Thus rated voltage is available at all times because SOLA Constant Voltage Transformers instantly correct fluctuations as great as 30% to less than ±1% of rated requirements. These sturdy, automatic transformers require no pampering or supervision. They protect both themselves and the equipment against line surges and short circuits.

Standard units are available in capacities from 10VA to 15 KVA or special units can be built to your specifications.

SOLA Constant Voltage Transformers

Don't forget to write for Sola's new Bulletin

Ask for Bulletin 10CV-102

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. **SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.**

Rotary speeds from 600 to 600,000 RPM — or vibrations from 10 to 10,000 CPS — can be "stopped" and studied with the Model 1200 Stroboscope. The light source is mounted in a small probe at the end of a five-foot flexible cable.

This makes it easy to examine small objects at close range. Provision is made to operate the unit from external tuning fork or crystal standards, where extreme accuracy is required. The motion of objects moving at irregular speeds may also be "stopped" with the Model 1200. An accurate repetitive pulse rate is obtained, as the pulses are derived from a stable audio oscillator.

Not only does this eliminate the necessity for constant readjustment of the repetitive rate, but it also insures clearly defined images at high speeds.

For greater flexibility, a light intensity control switch is also provided. This enables the user to control both the intensity of the light and the duration of the pulse length.

WRITE FOR DESCRIPTIVE BULLETIN

COMMUNICATION MEASUREMENTS LABORATORY

Rotobridge • Electronic Generators • Power Supply Units

120 GREENWICH ST., NEW YORK 6, N. Y.

WIDE READING

(*Continued from page* 170)

change in antenna reflector distance over the range of one quarter to three-quarter wavelengths. By using an antenna in the plane of a flat sheet reflector it is possible to obtain a polar diagram showing an almost uniform sensitivity for a signal received from any direction over an arc of 180 deg., combined with a reasonably sharp minimum when the sheet is in the plane connecting the transmitter and receiver. This property might be of use for direction finding purposes.

Dielectric Heating for Gluing of Wood

D. I. Lawson (Electronic Engineering, London, August, 1945)

An investigation is made into the relative efficiencies of longitudinal and transverse heating applied to the gluing of wood. In longitudinal heating the electric field is applied along the lines of glue, in transverse heating it is applied at right angles to the lines of glue.

Equivalent circuits for the two arrangements, assuming the load to be tuned to resonance, are considered and the following formulae are derived:

$$a_L = \frac{1}{1 + \frac{N\epsilon_w c \tan.\beta_w}{(N-1)\epsilon_g d \tan.\beta_g}},$$

$$a_T = \frac{1}{1 + \frac{N}{(N-1)}\frac{\epsilon_g c \tan.\beta_w}{\epsilon_w d \tan.\beta_g}}.$$

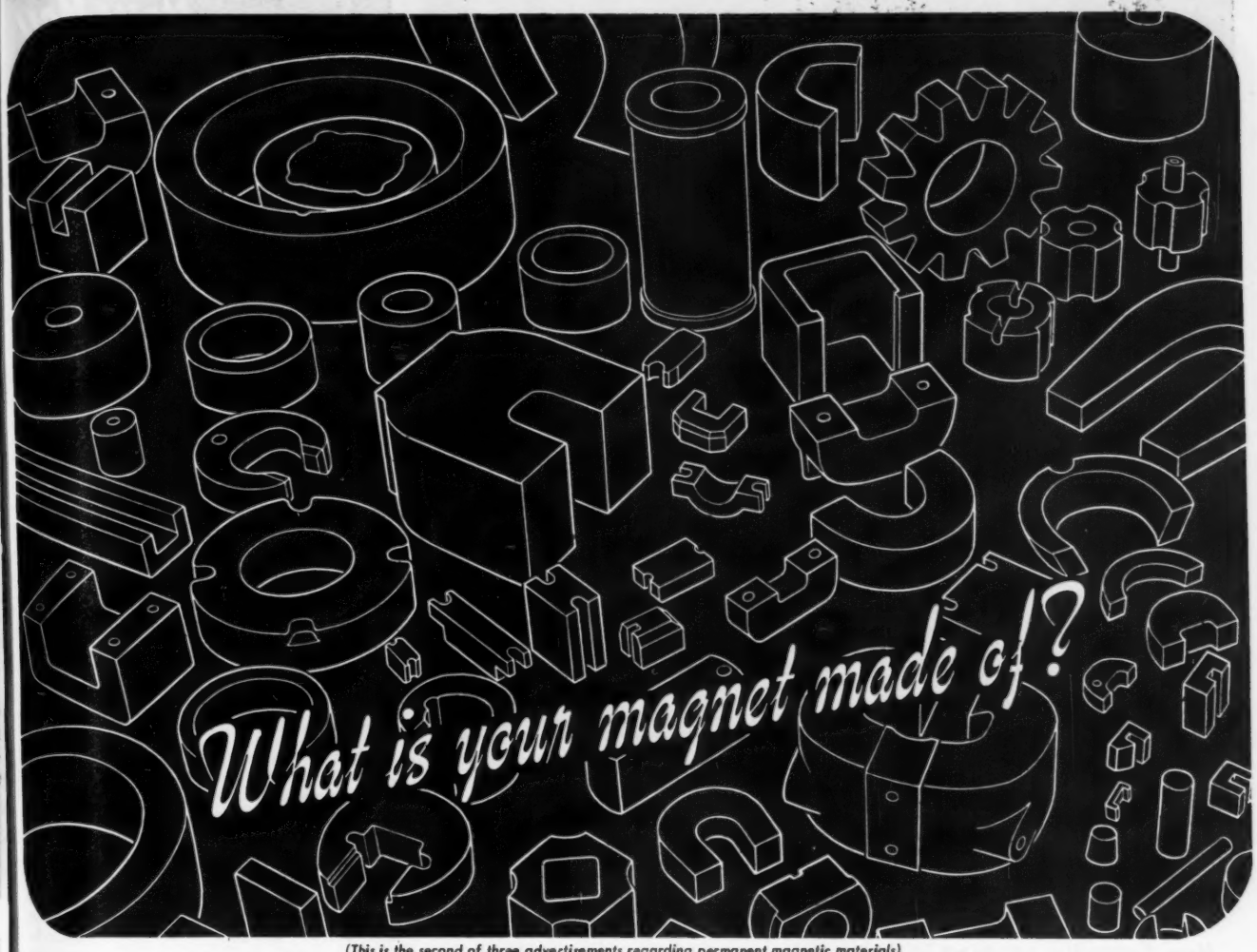
a_L is the fraction of the total radio frequency power dissipated in the glue line with longitudinal heating and a_T the same fraction for transverse heating; N is the number of wooden sections, N-1, consequently, the number of glue lines; ϵ_w and ϵ_g are the dielectric constants of wood and glue, respectively, while tan β_w and tan β_g are the power factors of wood and glue; c and d are the width of the wood and the glue sections, respectively.

The two formulae differ in that the dielectric constants of wood and glue are interchanged. To obtain maximum efficiency, longitudinal heating is to be preferred if the dielectric constant of the glue exceeds that of the wood and transverse heating if the dielectric constant of the wood exceeds that of the glue.

An advantage of longitudinal heating is that in dealing with thick wooden blocks it is possible in effect to reduce c by using a series of platens covering the glue lines only and missing the bulk of wood in between.

(*Continued on page* 178)

PERMANENT MAGNETS MAY DO IT BETTER



(This is the second of three advertisements regarding permanent magnetic materials)

ALNICO ALLOYS (Grades I-IV)

The precipitation-hardening alloys known as Alnico are composed of aluminum, nickel and iron, with the addition of cobalt and copper in some grades. Composition is varied to adapt the material to a wide range of requirements. All grades of Alnico have comparatively high coercive force, moderate residual induction (except Alnico V, which is high in both) and high available energy.

The Alnicos are hard, brittle, coarse-grained, non-forgeable and non-machinable. They are cast from coreless induction furnaces in sizes ranging from 1/10 ounce in weight to 110 pounds. Sintered Alnico is a mixture of powders of the constituent metals molded to desired shapes under extreme pressure. It is less brittle than the cast type, fine-grained, and can be produced in weights between 1/150 ounce and 3 pounds.

Close control of all steps of production is essential for obtaining the highest magnetic efficiency in the Alnico alloys; they must be poured over a narrow range of temperature, heated to just under their melting point for a measured period of time, cooled at a controlled rate and annealed at precisely controlled temperatures.

Better permanent magnet materials make possible improved operating results in many devices. Many products now using permanent magnets of less efficient materials should be re-designed to capitalize the latest developments. Consult our engineers on your problems in product design to get the best solution to your permanent magnet requirements. Write for technical handbook: "*Permanent Magnet Manual.*"

★★★ **THE INDIANA STEEL PRODUCTS COMPANY** ★★★

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SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

Permoflux Speakers and Transformers Set New Standards of Comparison!

New Permoflux speakers in a complete range of true-dimensioned sizes from 2" to 15", with power handling capacities from 1 to 20 watts, provide the finest sound reproduction for every application.

Permoflux midget transformers, with their many practical circuit applications, have literally revolutionized efficiency concepts where size and weight are determining factors.

Advanced engineering designs, improved manufacturing methods and new materials have all contributed their share in the development of Permoflux speakers, transformers, microphones and headphones. You can count on Permoflux to provide an acoustical unit to suit your exacting requirements.

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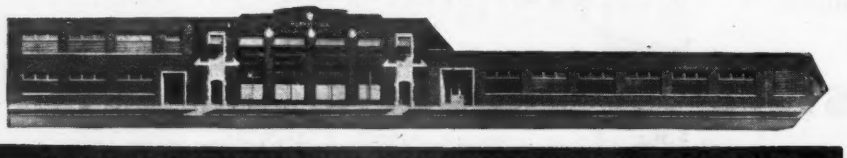
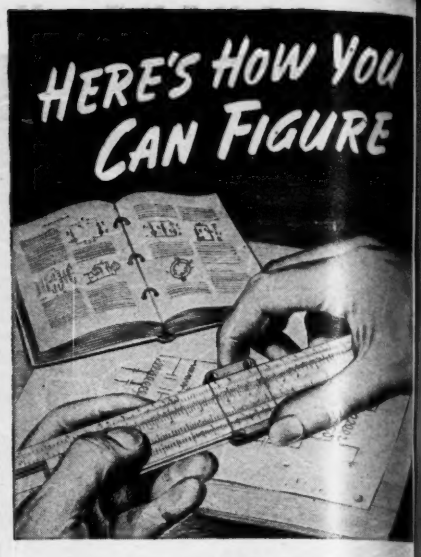


PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS



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Your ability to solve tough problems on paper and then follow-up with the necessary mechanical operation, is a true indication that you have the *confidence* born of *knowledge* . . . confidence in your ability to get and *hold* an important job with a secure, promising post-war future. Investigate now the CREI home-study course best suited to your needs, and prepare for security and happiness in the New World of Electronics! *Write for all the facts now.*

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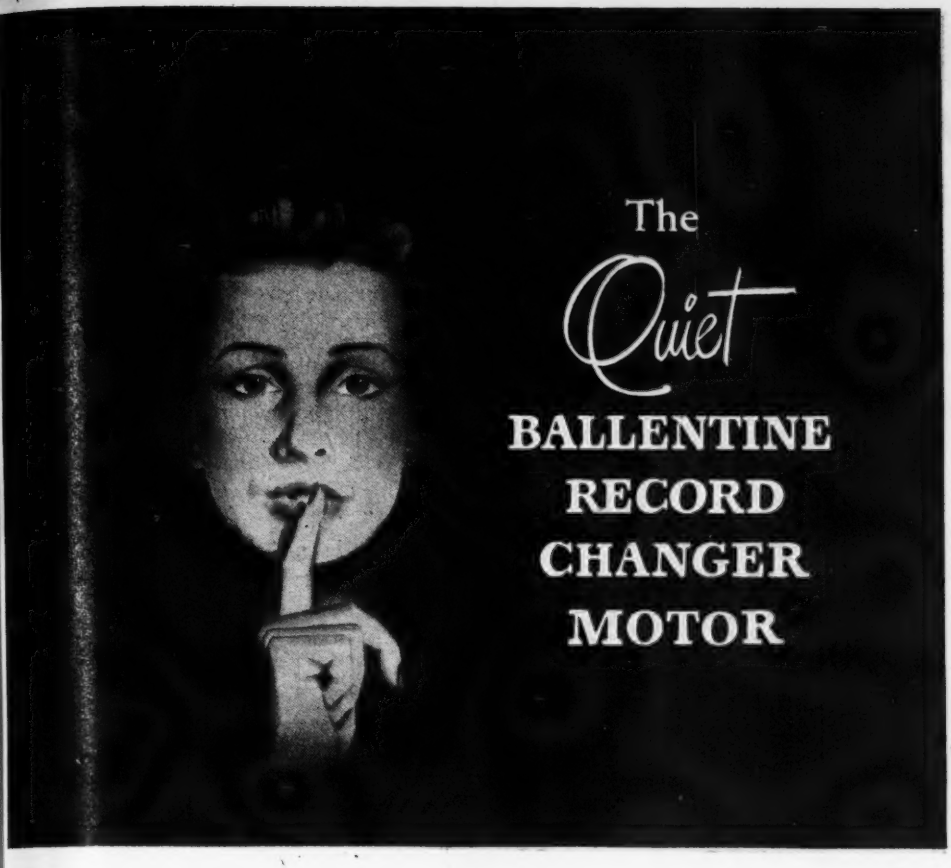

The *Quiet Ballentine* Changer Motor

has these four characteristics achieved by advanced design, skilled engineering and precision manufacturing

- **Lowest Rumble**
- **Highest Efficiency**
- **Most Compact Design**
- **Longest Life**

The *Quiet Ballentine* Changer Motor is recommended to record changer manufacturers seeking to provide the ultimate in performance.

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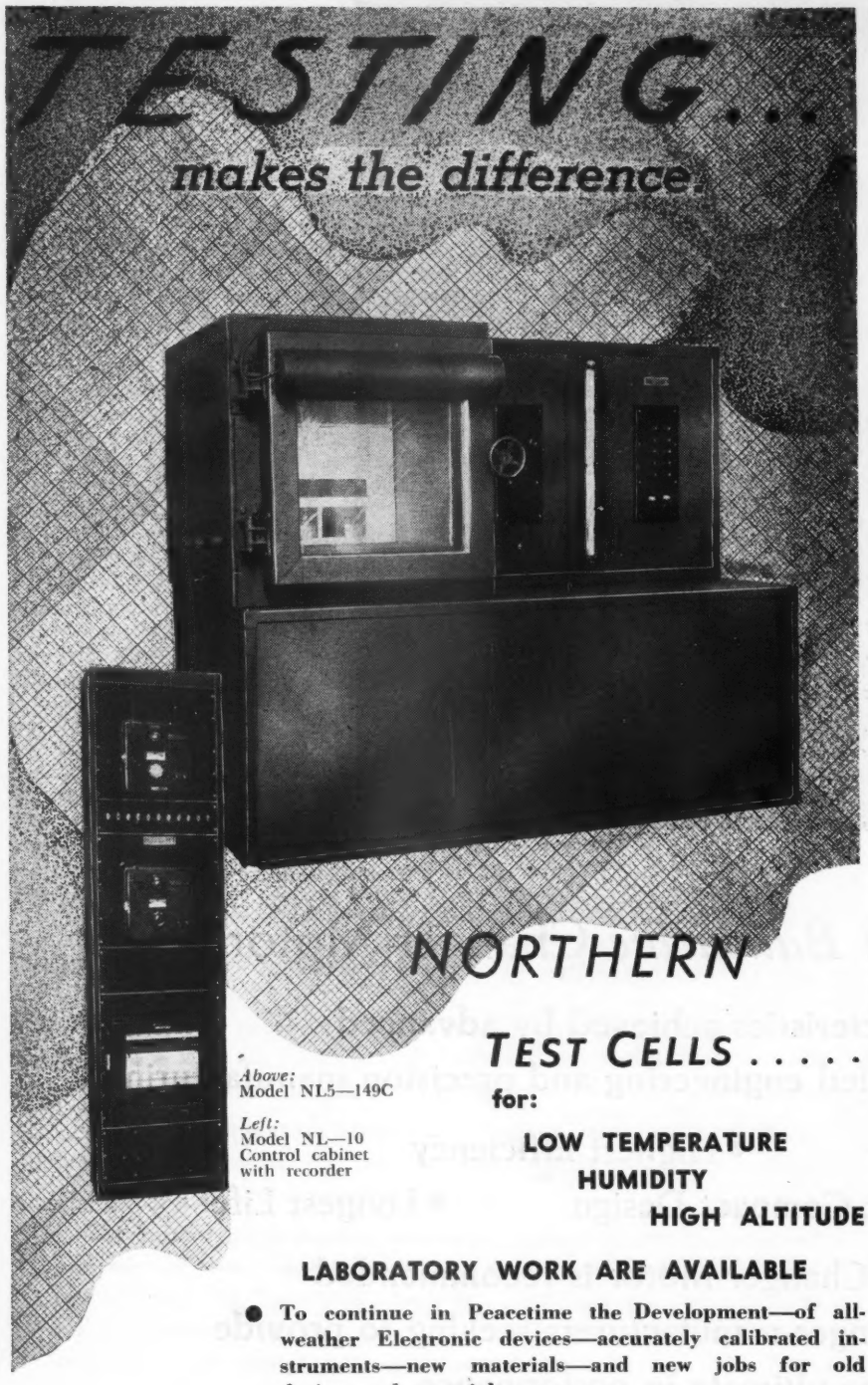
Manufacturers of **BALLENTINE RECORD CHANGER MOTOR**



Above:
Model NL5—149C

Left:
Model NL—10
Control cabinet
with recorder

NORTHERN

TEST CELLS . . . . .

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LOW TEMPERATURE
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- To continue in Peacetime the Development—of all-weather Electronic devices—accurately calibrated instruments—new materials—and new jobs for old devices and materials.
- Rapid delivery to speed your reconversion.
- Standard and special test machines to any temperature range with or without full automatic humidity control and with or without automatic vacuum control.
- Special cycling control with adjustable time cycle and multi-pen recorders for life test are also available.
- Write stating size of test space, and ranges required or better still request that one of our field engineers call to discuss your problem.
- We also offer a complete rebuilding, repair, and maintenance service for your hurriedly built wartime test chambers.

NORTHERN LABORATORIES LTD.

3-01 27TH AVENUE, LONG ISLAND CITY, NEW YORK

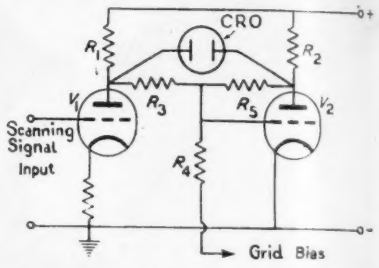
WIDE READING

(*Continued from page* 174)

Balanced Amplifier

E. M. I. Laboratories (Electronic Engineering, London, July, 1945)

It is frequently required to feed unbalanced signals to an amplifier feeding a balanced output circuit. A typical sawtooth wave amplifier for the sweep circuit of a cathode ray tube is shown in the drawing. Tube V_2 is driven by a fraction of the output voltage derived from the plate of tube V_1 and its output voltage developed across resistor R_2 is applied to one plate of the cathode ray oscillograph.



Balanced saw-tooth wave amplifier circuit

A resistor R_3 introducing negative feedback is inserted in this conventional circuit. It tends to prevent any deviation of the amplitude of the plate voltage of V_2 from the amplitude of the plate voltage of V_1 maintaining a balanced output. By suitable choice of the values of R_3, R_4 and R_5, the swings on the plates of V_1 and V_2 are made equal in magnitude and of opposite sign.

As the feedback path passes both ac and dc, the mean potential of the plates will also be stabilized. If ac balancing is not required, series capacitor may be inserted in the feedback path. On the other hand, should the dc stabilization be desired without ac stabilization, the feedback circuit must be designed to pass dc and no ac, as for example by including series inductance.

Bendix Establishes International Division

The formation of a new division, Bendix International, to handle the comprehensive foreign trade program of Bendix Aviation Corp., has been completed and will be under the direction of Charles T. Zaoral. The new division will handle throughout the world, with the exception of the United States and Canada, the products of the seventeen divisions of the corporation. It has established headquarters at the corporation's New York office, 30 Rockefeller Plaza.

NEW!

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$129.00* AMATEUR NET

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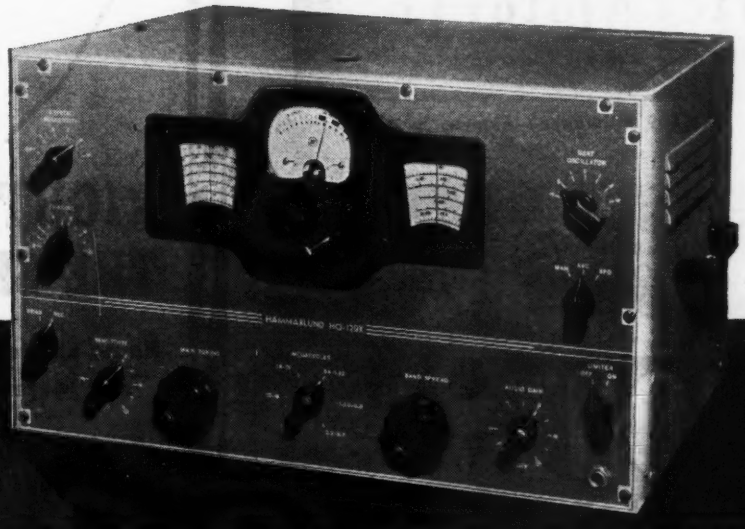

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By all measurement this is unquestionably one of the greatest values ever offered to amateurs . . . Here is "ham" communication at its best, streamlined for highest performance at a modest cost . . . WRITE TODAY. Send card for descriptive folder.

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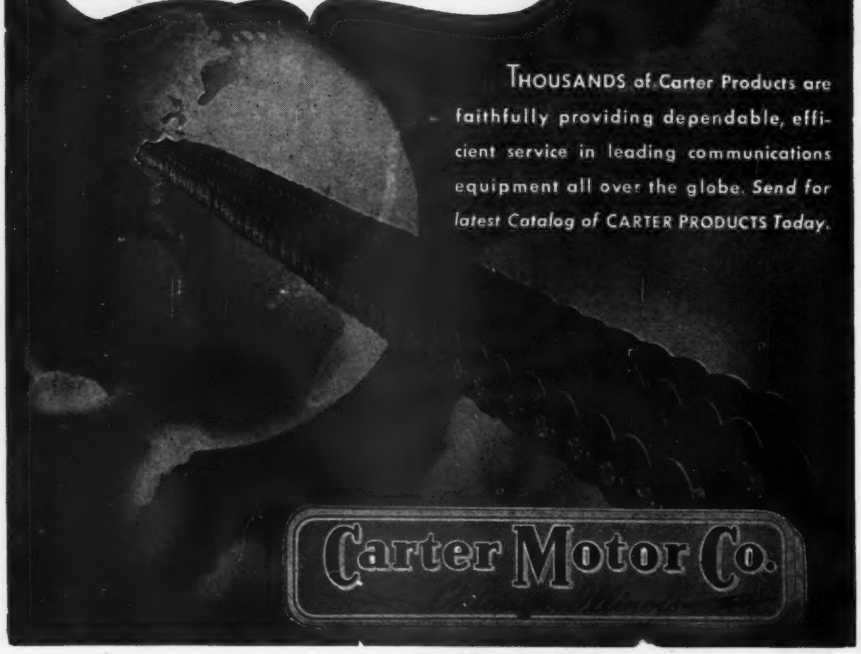
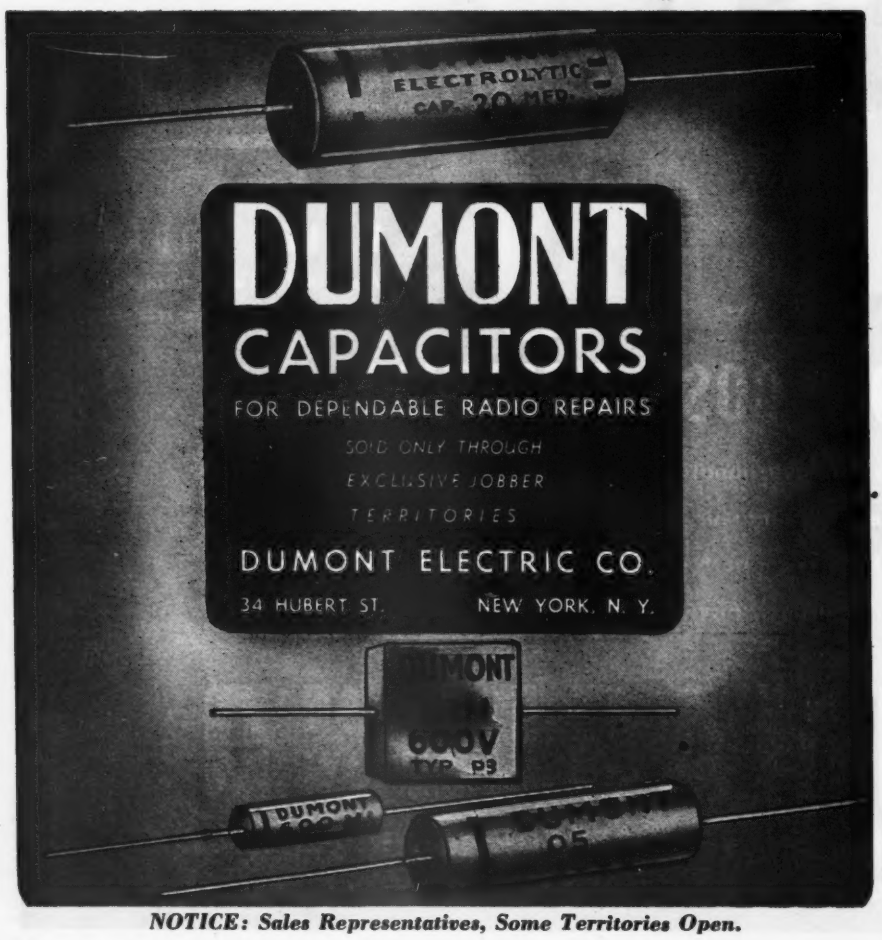
Preferred in World Famous Communications Equipment



THOUSANDS of Carter Products are faithfully providing dependable, efficient service in leading communications equipment all over the globe. *Send for latest Catalog of* CARTER PRODUCTS *Today.*

Carter Motor Co.

1609 Milwaukee Avenue



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● Shaped like a turtle's shell, this "Feed-Through" plate supports antenna leads at the point of entrance to a powerful radio transmitter.

This component is molded for the Collins Radio Company by G.E.'s *complete* plastics service from G-E mycalex . . . compound of glass and powdered mica with a unique combination of properties.

G-E mycalex could be molded to exacting contour specifications . . . to control creepage of high frequency current . . . to give the required mechanical strength.

Maybe G-E mycalex and new G-E molding techniques can solve your high frequency insulation problem.

G-E mycalex is available to all manufacturers . . . in standard sheets or rods or molded to your design. For information, write to Section T-3, Plastics Divisions, General Electric Company, 1 Plastics Avenue, Pittsfield, Massachusetts.

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A Unique Combination of Properties

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2. Low power factor
3. Prolonged resistance to electrical arcs
4. Chemical stability—no deterioration with age
5. Dimensional stability—freedom from warpage and shrinkage
6. Imperviousness to water, oil, and gas
7. Resistance to sudden temperature changes
8. Low coefficient of thermal expansion
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RESEARCH • DEVELOPMENT • MANUFACTURING

STRAIN GAGE

(*Continued from page* 79)

tween the strain gage circuit and the oscillograph galvanometer, inasmuch as the available power output of the strain gage bridge circuit is insufficient to drive the galvanometer directly.

If a source of direct current power is applied to the strain gage bridge, the output of the bridge during the measurement of dynamic strain will be a varying or an alternating current of the same wave shape as the strain itself, and the amplifier must be designed to handle all of the frequency components contained in the strain pattern. If the strain is maintained at a steady value for any appreciable time and it is necessary to measure this steady value, the amplifier must be direct-coupled so that its response will go down to zero frequency. The upper limit of uniform frequency response must be high enough to handle the highest strain frequency component that will be encountered or that it is desired to measure.

Amplifiers to cover a wide range of dynamic response, such as from 5 to 1500 cycles per second, are reasonably simple and stable, but direct-coupled amplifiers designed to go down to zero frequency are unwieldy and usually unstable, hence it is usually unsatisfactory to measure static strain by means of circuits utilizing a direct current in the strain gage bridge circuit.

When it is desired to measure static as well as dynamic strain, the usual procedure is to supply the strain gage bridge circuit with an alternating carrier voltage three or four times higher in frequency than the highest strain frequency component to be measured. The output of the strain-gage bridge will then be an alternating current of carrier frequency amplitude modulated by strain. The amplifier can then be designed to handle the carrier with side bands which constitute a relatively narrow frequency band that does not approach zero as a lower limit.

The use of a carrier supply to the strain gage bridge makes possible a very simple and stable amplifier, capable of measuring static as well as dynamic strain.

Circuits

Circuits. Fig. 13 shows a typical amplifier circuit for direct current in the strain gage circuit and a wide-band low-frequency ac amplifier. This diagram shows the strain gage bridge, the oscillograph galvanometers and the intermediate amplifier equipment. This is the circuit used in the type MRC-10AC amplifier element, and is capable

(*Continued on page* 186)

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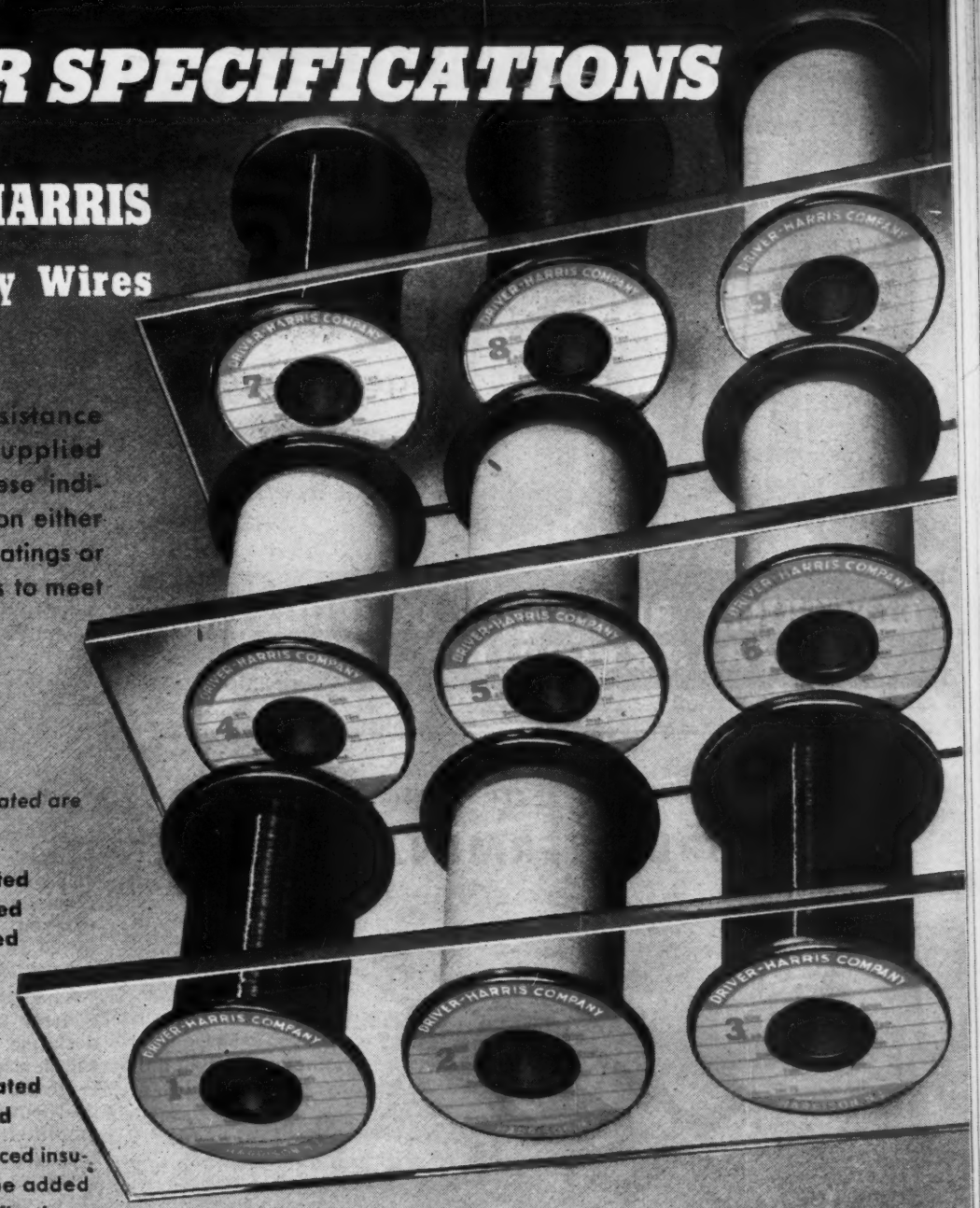

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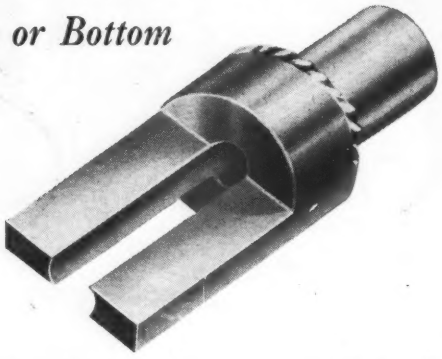

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STRAIN GAGE

(*Continued from page* 182)

of providing a flat strain frequency response on the record from 3 to 3000 cycles per second.

Fig. 14 shows a typical amplifier circuit using a carrier in the strain gage circuit, and an amplifier with flat frequency-response over a range wide enough to cover the carrier and both side bands. This circuit has a phase-selective demodulator in the output circuit that removes the carrier and that provides for galvanometer deflection in one direction for strains of compression and in the other direction for strains of extension. The galvanometer receives a varying current for varying strain, the strength of which is instantaneously proportional to strain. This circuit uses a 5000-cycle carrier and provides a flat strain frequency response from 0 to 1500 cycles per second.

Multi-channel unit

Typical Apparatus. The type MRC-10 strain gage control unit is shown in Fig. 15. This is a 12-channel unit, for which three types of amplifier elements are available which can be inserted in the control unit in any desired combination. The MRC-10AC amplifier element, circuit diagram shown in Fig. 13, uses direct current in the strain gage circuit and provides a frequency response of 0 to 1500 cycles per second. A third element is a double-integrator unit that can be used in connection with an accelerometer unit to provide displacement records. The unit has external dimensions of 14 in. long by 23 in. wide by 15 in. high, and weighs 123 lb.

The type MRC-12 strain-gage control unit is a six-element unit designed for application where small size and extreme portability is of paramount importance. This unit contains six separate carrier amplifier elements, a carrier power supply oscillator, and all necessary batteries for its operation mounted in a case only 12 x 8 x 7 in. external dimensions. The total weight of this unit, including batteries, is less than 25 lb. A carrier frequency of 2000 cycles is used, and a flat strain frequency response of 0 to 500 cycles per second can be obtained.

Power supply equipment

Power requirements for strain-analysis equipment depend on the type of strain gage employed, and on the type of circuit. Large inductance gages used to drive the oscillograph galvanometer directly re-

(*Continued on page* 190)

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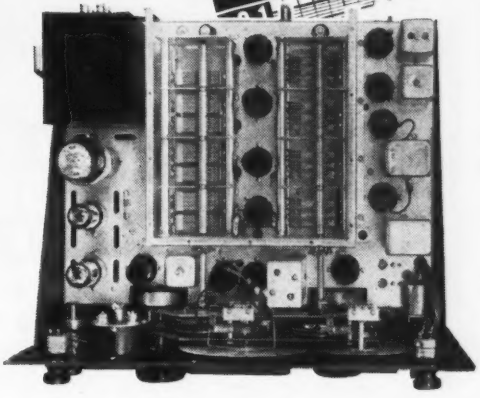

HALLICRAFTERS Super Skyrider, Model SX-28A, covers the busiest part of the radio spectrum – standard broadcast band, international short wave broadcast bands, long distance radio telegraph frequencies, and all the other vital services operating between 550 kilocycles and 42 megacycles. Designed primarily as a top flight communications receiver the SX-28A incorporates every feature which long experience has shown to be desirable in equipment of this type.

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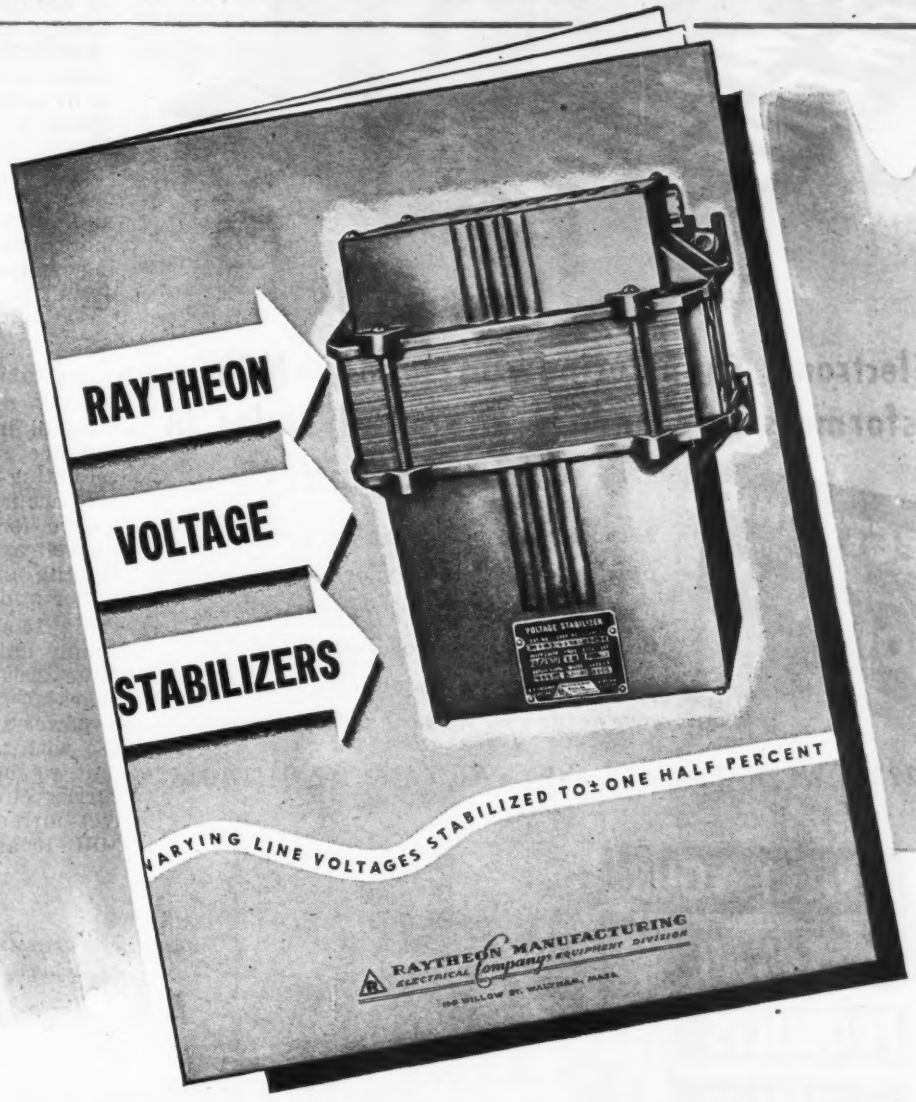

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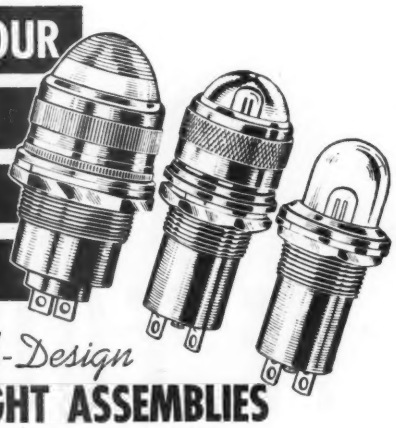

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STRAIN GAGE

(*Continued from page* 186)

quire only a source of carrier power accurately controlled in regard to voltage and frequency. A frequency of 2000 cycles is usual for gages of this type, and this can be supplied by a rotating attenuator or by a vacuum-tube oscillator, followed by a power amplifier. The latter type of supply has been found superior to the former because of better voltage regulation and because it has been found more difficult in the case of rotating equipment to keep the carrier output free from 60-cycle superimposed voltages.

Power supply

Small inductance gages and resistance gages operating in an attenuating-current bridge require an accurately regulated carrier source for the strain gage circuit as well as regulated direct current for the anode circuits on the amplifier and oscillator equipment.

Fig. 16 shows an electronic power supply unit to supply power for 24 large 2000-cycle inductance strain gages at the left. At the right is a power-supply unit designed for use with the type MRC-10 control unit, to supply 5000-cycle power for carrier circuits, as well as all direct-current power required by the MRC-10 amplifier elements.

Hammarlund's Death Reveals Inventions

Oscar Hammarlund, founder of the Hammarlund Mfg. Co. Inc., New York, died August 25, 1945, at his home in Brooklyn at the age of eighty-three. In 1886 he joined the Western Electric Co. as superintendent at Chicago. Six years later he went to the Gray National Telautograph Co., now Telautograph Corp., where he assisted Elisha Gray, co-inventor of the telephone, in the development of the technique of transmitting actual writing over wires. One of his outstanding contributions was the automatic stylus used in the telautograph machine. That automatic stylus was the forerunner of the present day propelling and repelling pencil. During his association with Professor Gray, Mr. Hammarlund developed a keen interest in radio communication. In 1910 he left Professor Gray's organization to found his own company for the purpose of developing his own inventions. He leaves a son, Lloyd A. Hammarlund, and three grandsons, Lt. L. A. Hammarlund, Jr., Sgt. Frazier S. Hammarlund, and Roger Hammarlund.

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The chart on this page shows the results of tests at 50 Mc. conducted on a standard Eimac VC50-32 Vacuum Capacitor and three other 50 mmfd. vacuum capacitors, designated on the chart by "A," "B" and "C." At just over 17 amps. (approximately 1525 peak volts across the capacitor) Unit "A" (rated at many times the applied voltage) became sufficiently heated to melt the solder on the end caps. Under this same test, the Eimac VC50-32 operates at less than 70°.

Eimac introduced the vacuum capacitor in 1938. It is interesting to note that the original Eimac capacitor design is still outperforming all comers. Such outstanding performance is typical of all Eimac products, which is one of the reasons why they are first choice of leading electronic engineers throughout the world.

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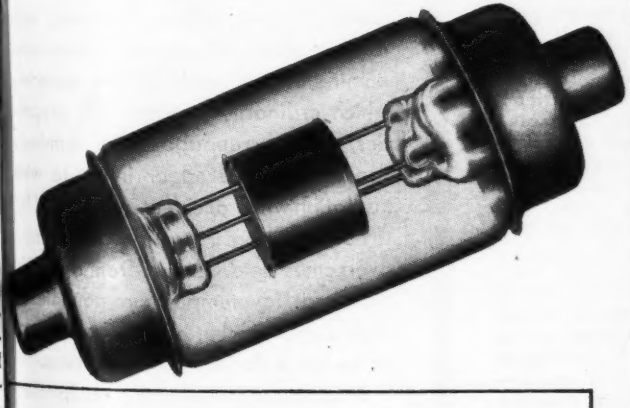

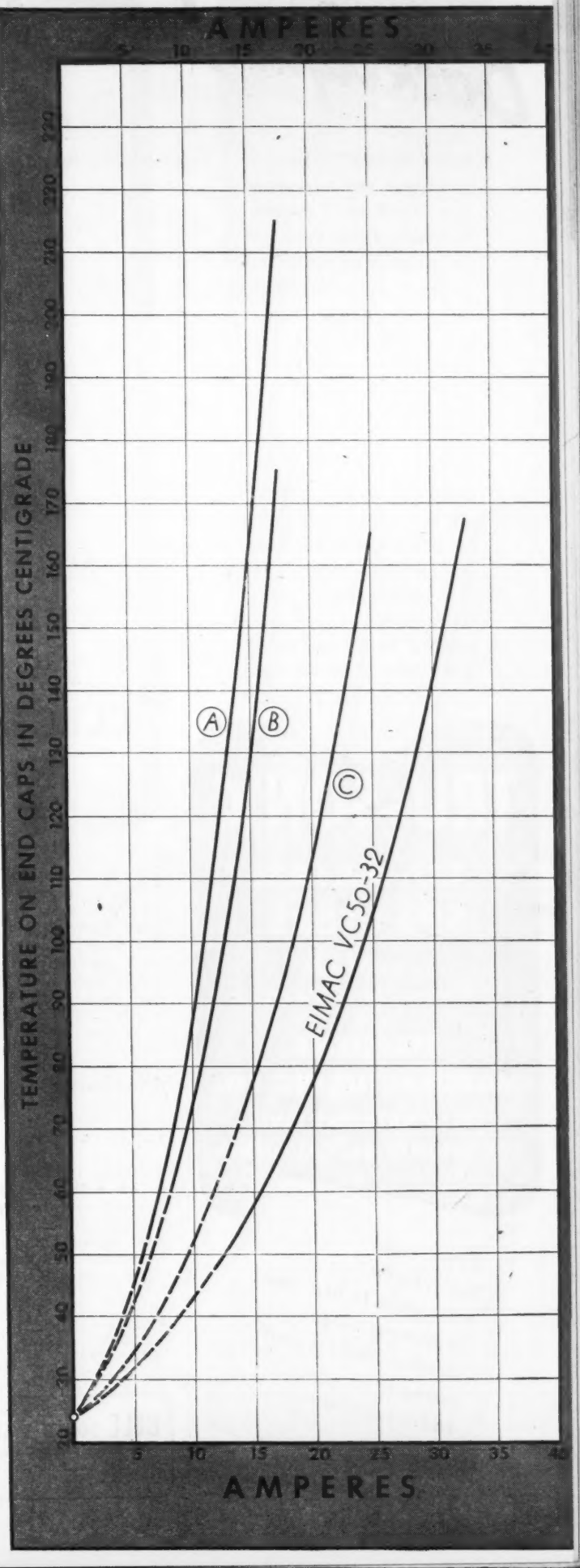

EIMAC VACUUM CAPACITOR TYPE VC50-32

General Characteristics

Mechanical:

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Maximum Peak Voltage	32,000 volts
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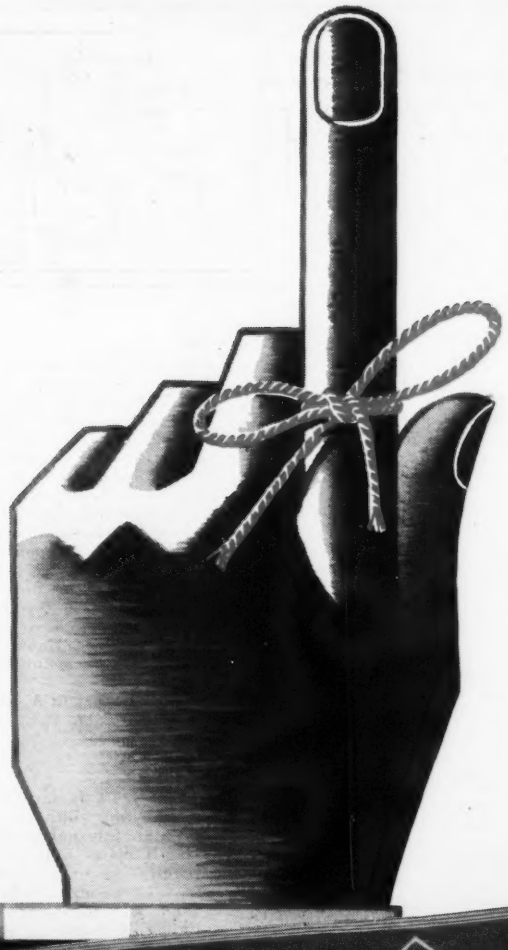

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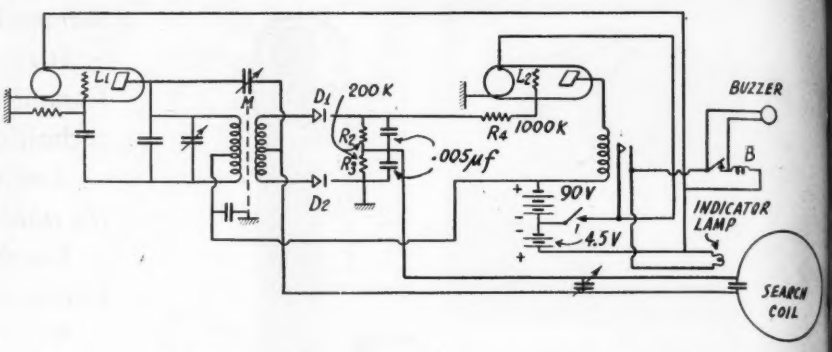
NEW PATENTS

(*Continued from page* 128)



are in phase quadrature, no output is obtained and R_4 is at ground potential. As soon as a metallic object reduces the apparent self-inductance of the search coil, the two voltages are no longer in phase quadrature, an output is obtained across R_4, causing the grid of L_2 to cut off current through the tube; this will actuate the control relay Q and the buzzer and indicator lamp will respond.

H. Chireix, Alien Property Custodian, (F) November 18, 1941, (I) May 22, 1945, No. 2,376,659.

FM Detector

The invention relates to an FM detector for extremely short waves below one meter which avoids the need for conventional resonant circuits. A metallic baffle 1 provided with many parallel slits 2 of the order of one wavelength wide constitutes a diffraction grating for the incoming waves. The component waves behind the baffle combine to form an interference pattern with maxima and minima of intensity. Energy collectors, for instance, dipole antennas or probes, are located at the points where the interfering waves add for maximum reception. Curves 3 represent the instantaneous wave fronts at a given instant. Zones of minimum field strength, zones of maximum field strength with frequency selectivity (i.e., the zones shift with frequency), and zones with maximum field strength with no frequency selectivity (i.e., the zones are locii of maximum field strength for all frequencies) are indicated on the drawing.

Obviously, the energy collectors 4 for frequency discrimination should be located in the latter region, as shown. The equivalent electric length of the dipole collector should be approximately one-half wave-length; a probe may be used instead of the dipole. A plurality of probes or dipoles are preferably located at different maxima and their output combined. A concave grating can be used instead of the planar baffle, in order to produce focusing in the manner of optical gratings and thus avoid most of the multiple probes.

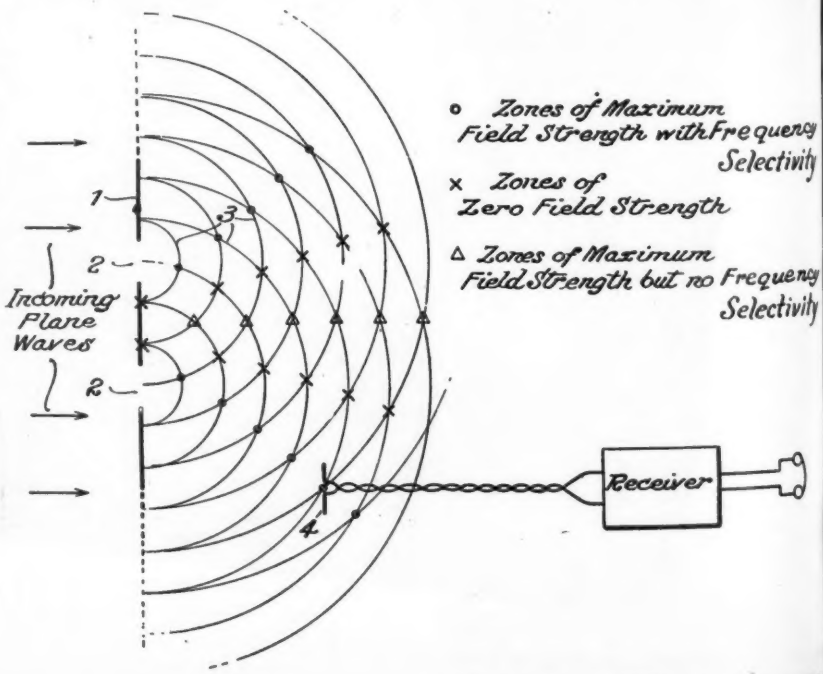
For discriminator action, the energy collectors are placed at maximum reception for the maximum frequency deviation to either side of the carrier. Less energy will be picked up at the unmodulated carrier frequency, and still less energy for the maximum frequency deviation to the other side of the carrier. Consequently, the received energy will be a function of frequency, as desired.

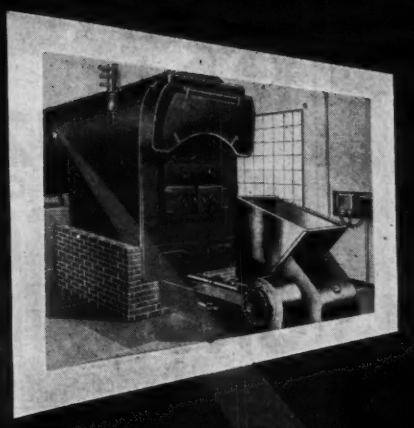
W. R. Ferris, RCA, (F) January 30, 1942, (I) January 23, 1945, No. 2,367,764.

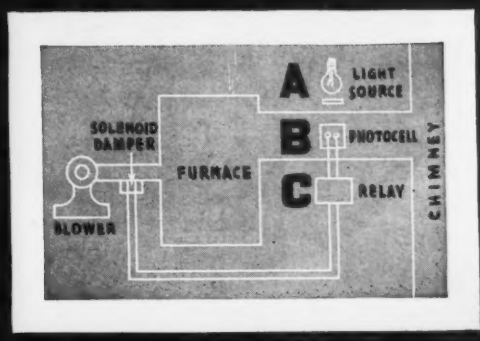
PH Meter

The circuit is intended for measurement of small dc voltages across a source of very high internal impedance, for instance, as a pH meter indicating the hydrogen ion concentration of a solution. For this purpose the unknown voltage E_{pH} is compared to the known, adjustable voltage E, the voltage difference is converted into an ac voltage by variation of the capacitance of capacitor 3. Upon amplification in tubes 6, 7 and 8, the ac voltage is applied to the second section of tube 8 which acts as a cathode ray indicator. For zero input, the fluorescent surface of the indicator is a minimum and is of constant size; for dif-

(*Continued on page* 198)







How to stop smoking with smoke

Typical of the applications possible with a Bradley Luxtron* photo*cell* is this suggested means of smoke control in a stoker-fired furnace.

Light source "A", beamed through the smoke stack to photo*cell* "B", will cause the cell to generate power sufficient to close relay "C" until smoke diminishes the light. Or the system could be arranged to close the relay when light is reflected by smoke particles.

In any event, resistance to vibration and temperature changes make the photo*cell* ideal for such an application. As in any photo*cell* application, it is as simple as A, B, C—and the "B" stands for Bradley.

Write Bradley for literature and complete engineering assistance on any photo*cell* application you may have in mind.

Write for Rectifier Data

Bradley also has available a complete line of unique copper oxide rectifiers, featuring mounting flexibility, pre-soldered terminals for ease and safety in assembly, low forward resistance with high leakage resistance, and gold coating of pellets to provide long life.

Data on five basic models are included in an illustrated Bradley "Coprox" Rectifier bulletin sent on request. Please write for it.

*TRADE MARK REG U S. PAT. OFF.

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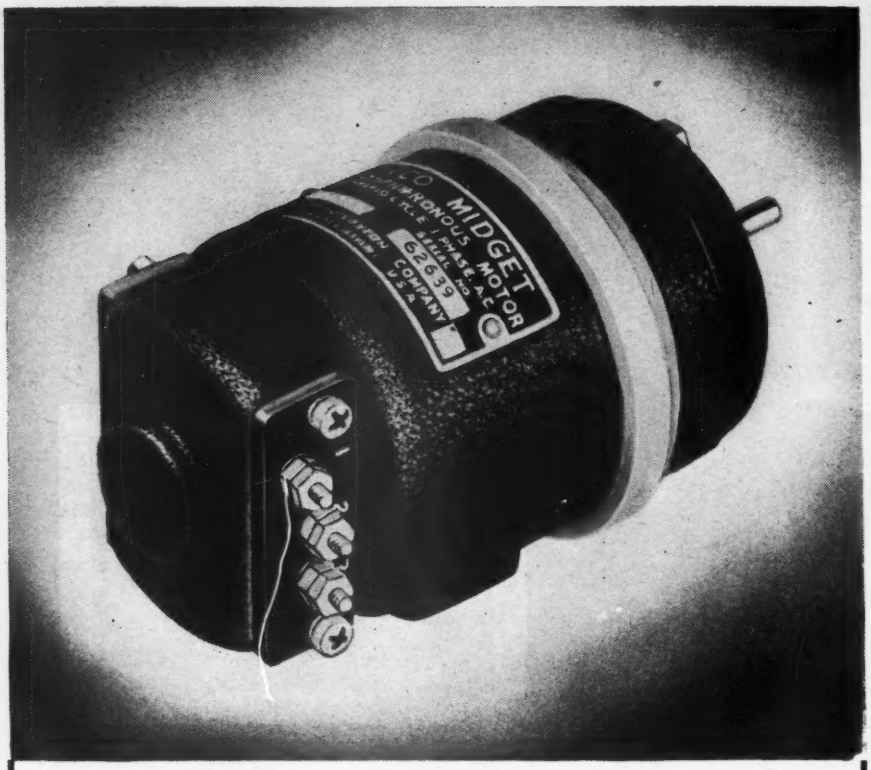
BRADLEY LABORATORIES, INC., 82 MEADOW STREET, NEW HAVEN 10, CONNECTICUT



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PRECISION FRACTIONAL HORSEPOWER MOTORS and GENERATORS

Type FB units are newly engineered to meet most exacting requirements for fractional horsepower motors and generators. Available as D.C. permanent-magnet generators or motors, D.C. shunt-wound, series-wound or split-field motors. D.C. motors can be wound to operate on voltages from 6 to 115 v. Also available in A.C. types as permanent-magnet generator wound to generate 2-pole single phase, 2 phase or 3 phase; as A.C. series motor with power supply up to 115 v., 60 cycles, single phase; also as universal series motor up to 115 v. Efficiency of motors as high as 45-60% on some applications.

Stainless steel shafts, aluminum die-cast housing finished in baked enamel. Overall dimensions 4" long (exclusive of shaft) by 2½" over flange. Designed for either base or flange mounting. Weight from 26 to 32 oz. according to type.

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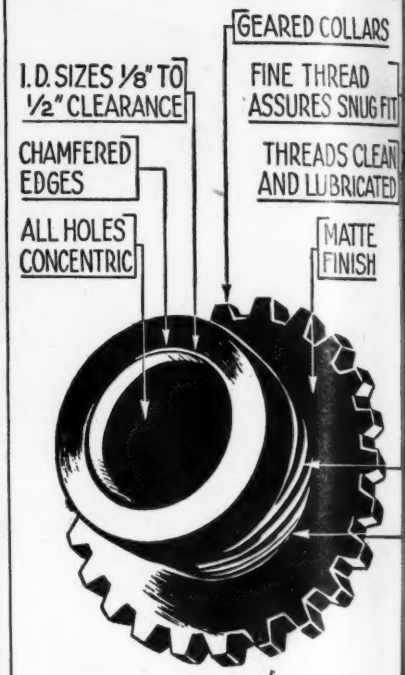

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Severest wartime uses prove beyond question the superior qualities of all three BH Fiberglas Sleevings in electrical applications for home and industry. One of them may fit your needs to a "T"—*plus!* Write for free BH samples today and put them to the toughest tests your product can dish out!

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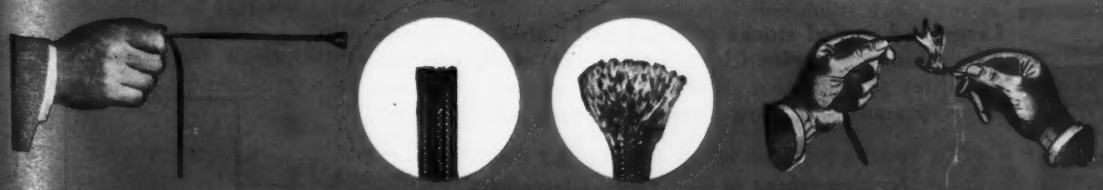

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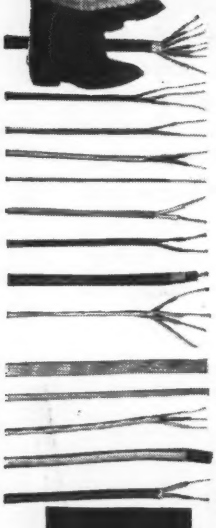

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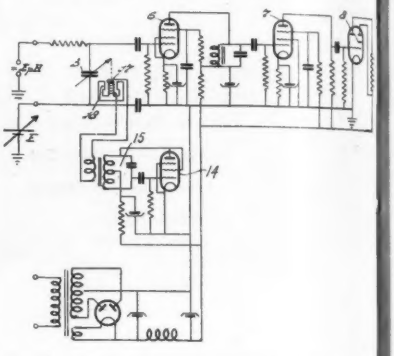
NEW PATENTS

(*Continued from page* 194)

ferent voltages E and E_{oH}, and consequent ac voltage at the amplifier output, the fluorescent surface is larger and varies in the rhythm of the ac voltage.

The accuracy of the results of this method may be impaired if the supply voltage or a harmonic of the supply voltage has the same frequency as the ac voltage furnished by the capacitor. Undesired coupling may be responsible for erroneous results. It is the purpose of the invention to avoid this difficulty by the use of generator 14 which supplies an ac voltage the frequency of which depends only on the circuit constants of tank circuit 15 and which



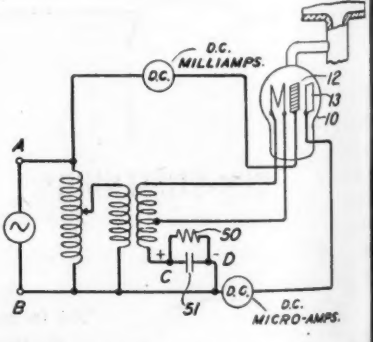
is chosen to be different from any frequency likely to be present in the supply voltage. The capacitor 3 is rigidly connected to the movable coil 17 arranged in the field of magnet 18; the current through the coil is supplied by generator 14 and it moves at the frequency of the generated oscillations different from the supply frequency and its harmonics.

C. Dorsman, Alien Property Custodian (F) December 24, 1942, (I) March 20, 1945, No. 2,372,062.

Manometer Circuit

As is well known, the ratio of the electron current to the positive grid 12 to the ion current to the negative plate 13 is proportional to the gas pressure in the manometer tube 10. It is a disadvantage of this method that the leakage current between grid and plate makes the result inaccurate.

The invention has for its object to eliminate or reduce the effect of the leakage current. An alternating voltage is applied between grid and plate, and a capacitor-resistor combination 50,51, providing less



voltage than the alternating voltage employed is used to bias the plate negative with respect to the cathode. Direct current meters are used in the plate and grid circuits and as the leakage current between grid and plate is alternating, the meters do not indicate it.

C. J. Calbick, Bell Telephone Laboratories, Inc., (F) March 2, 1943, (I) May 8, 1945, No. 2,375,280.

(*Continued on page* 202)

RAYTHEON

TYPE CK1012

A High Current, Medium Voltage Gas Rectifier

The Raytheon type CK1012 full wave gas rectifier was developed to supply the requirements at high rectification efficiency for those applications which require more power than is obtainable with conventional receiving tubes and yet cannot justify the size and expense of transmitting type tubes. In this category are the larger fm and television receivers and small fixed or mobile transmitters.

The CK1012 is contained in an ST-14 bulb, which is the size of a type 80. The emitter can be directly heated — or, under the proper conditions noted below, ionically heated for greater efficiency and elimination of heater windings.

The very rugged construction is ideal for mobile equipment, and the use of an inert gas allows it to operate over a wide range of ambient temperature. No preheating time is required, and consequently full output is obtainable almost instantly. Any tendency to generate noise in radio frequency applications can be minimized by proper filtering and shielding of the tube and associated wiring.

Whether or not CK1012 fits your requirements, it is an example of the advanced engineering and painstaking manufacture found in the entire Raytheon tube line. For best results, specify Raytheon High-Fidelity Tubes for your postwar products.

TYPE CK1012 RATINGS — FULL WAVE RECTIFIER SERVICE

	IONICALLY HEATED*	DIRECTLY HEATED	
Filament Voltage	0	1.75	volts
Filament Current	0	2.00	amp
Maximum Peak Inverse Voltage	1200	1200	volts
Average D.C. Voltage Drop	25	20	volts
Maximum D.C. Output Current	300	300	ma
Minimum D.C. Output Current	70	0	ma
Minimum Starting Peak Voltage	400	300	volts
Maximum Steady State Peak Anode current per anode	900	900	ma

This condition is not recommended for rapid intermittent operation

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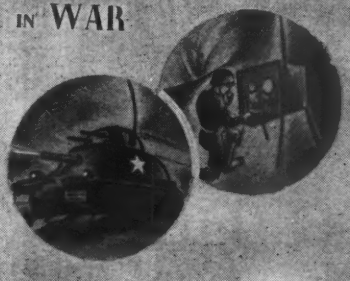

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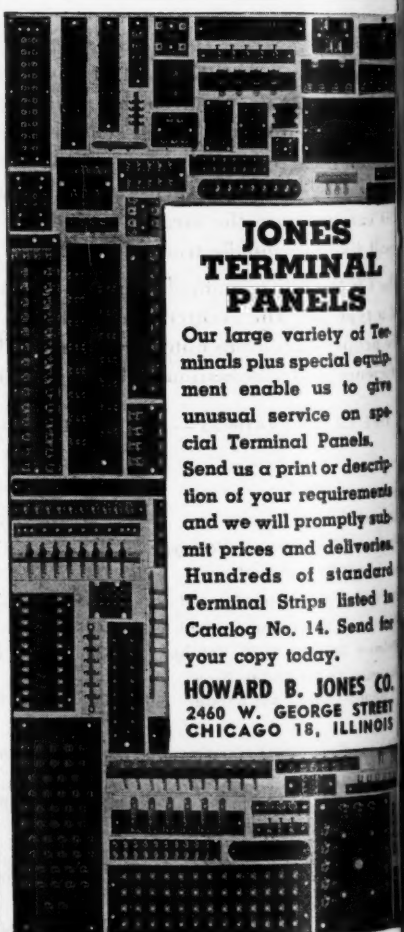

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The exact counterparts of these efficient and precision-engineered "veterans" are now available in quantities for your own essential requirements.

Their construction features, resistance-temperature characteristics and specifications are described fully and charted graphically in Bulletin #3 which will be sent to you upon request directed to Dept. 2-J.

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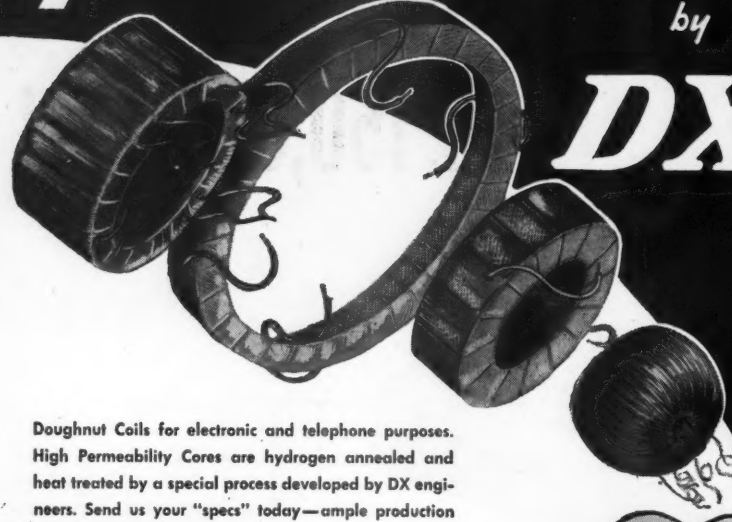

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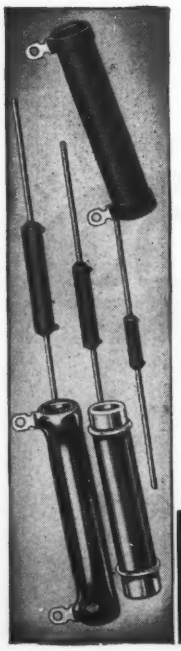
GROVES

wire wound RESISTORS



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Precision Resistors, non-inductively wound on high quality ceramic spools, are effectively processed to withstand high humidity conditions. Moisture and fungus resistant. Constructed in accordance with the joint Army and Navy specifications. 3 types immediately available.

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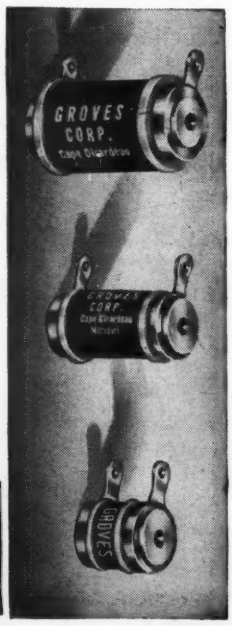


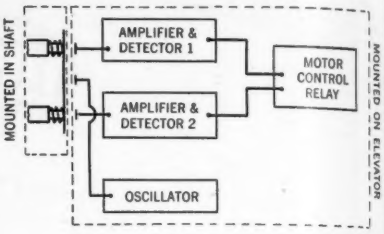
GROVES
CORPORATION
CAPE GIRARDEAU · MISSOURI

NEW PATENTS

(*Continued from page* 198)

Floor Leveler for Elevators

It is intended to provide a mechanism to stop an elevator automatically at the exact level of one of the landings. The operation of the apparatus will be clear from the accompanying diagram. As soon as the elevator approaches the region of the landing, the oscillations generated by the oscillator



will be capacitively coupled to amplifier and detector I or II, depending on whether the elevator is too low or too high in the shaft. Corresponding operation of the motor control relay will cause the elevator to be raised or lowered as required.

W. Muller, Brujac Electronic Corp., (F) September 29, 1944, (I) May 8, 1945, No. 2,375,435.

Shear Modes in Piezo-electric Crystals

The following report by S. Bhagavantam and D. Suryanarayana appeared in the February 10, 1945, issue of Nature, London:

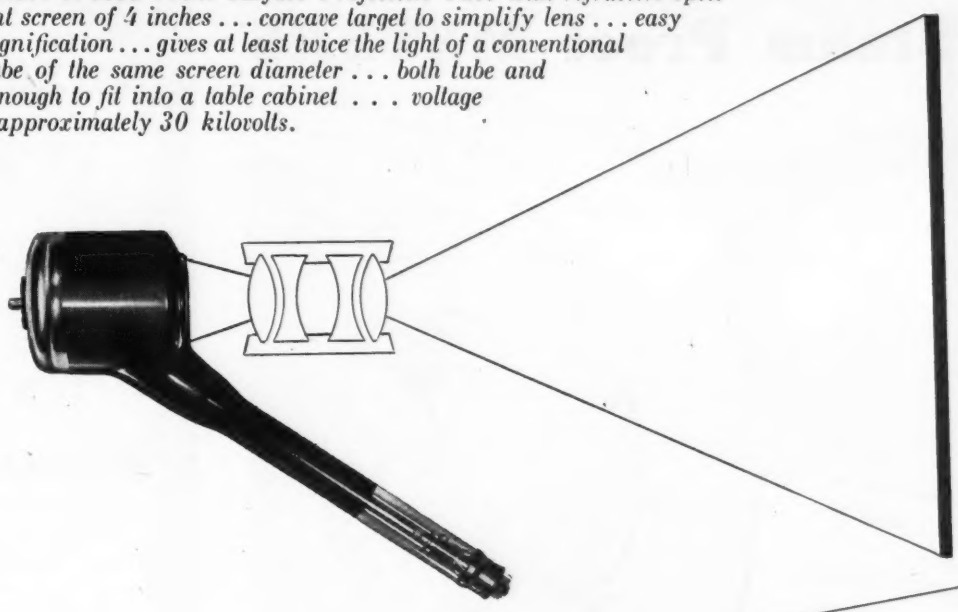
"While investigating the diffraction patterns produced by ultrasonic waves set up in a liquid medium by piezo-electric crystal plates, we made the following observations. Besides the usual thickness longitudinal mode, diffraction patterns corresponding to thickness transverse or shear modes have been observed occasionally. We find that the appearance of such patterns is facilitated when the crystal plates are either silvered in patches only, or so prepared that there is a deviation from the normal cut. When irregular silvering is adopted, not only do the odd harmonics of the shear modes make their appearance, but also the even harmonics of all the modes begin to show up. Such results have been observed by us in differently oriented plates of quartz and tourmaline and used for determining the elastic constants corresponding to the shear modes of these crystals. Details of these investigations are being published elsewhere.

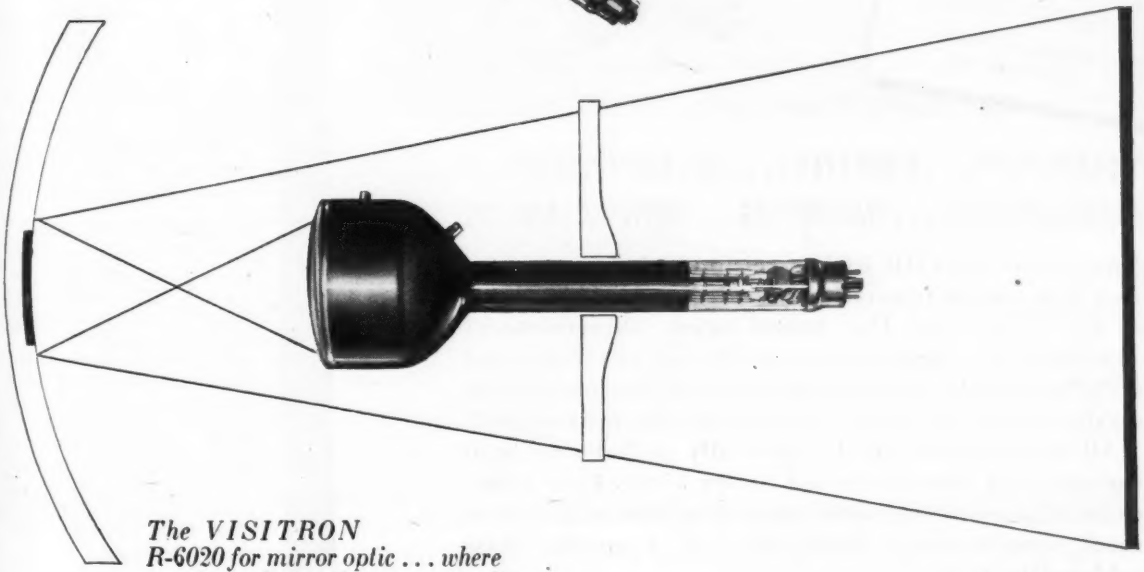
"These observations mean that particular shear modes cause longitudinal strains in the crystal plates resulting in corresponding longitudinal ultrasonic waves in the liquid. The phenomenon is presumably connected with the coupling between the longitudinal and shear modes produced either by the finite size of the plate or the cut of the plate, being such that the modes themselves are inherently coupled."

Projection Tubes for Home Television

Pioneering experience in the development of large screen television projection has given *Rauland* physicists and engineers the "know-how" necessary to produce projection tubes for home television receivers.

The VISITRON R-6016 Front Surface Projection Tube with refractive optic . . . fluorescent screen of 4 inches . . . concave target to simplify lens . . . easy change of magnification . . . gives at least twice the light of a conventional projection tube of the same screen diameter . . . both tube and optic small enough to fit into a table cabinet . . . voltage requirement approximately 30 kilovolts.





The VISITRON R-6020 for mirror optic . . . where maximum light at lower anode voltage is desired . . . 5 inch diameter fluorescent screen.

Consult with *Rauland* about your television tube problems. We have the facilities to build projection tubes to special requirements.

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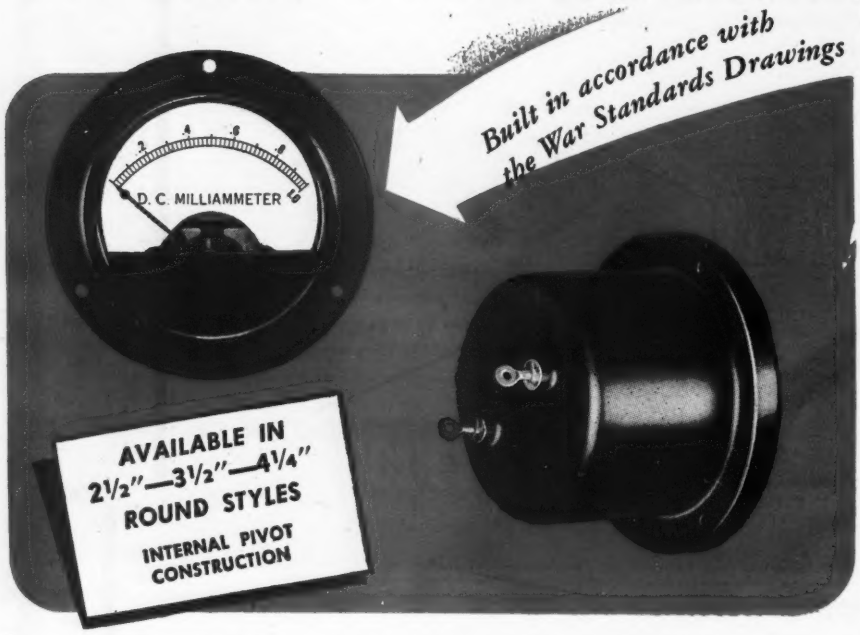

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All instruments are hermetically sealed and both vacuum and pressure tested under water. Case fabricated of pressed steel and made corrosion resistant to meet specifications. Terminals are a special glass soldered-in type.

All meters are fully shielded, permitting use on either magnetic or non-magnetic panels. Operation is accurate and dependable even up to 85° centigrade. Internal pivot construction in D.C. types assures longer life and greater resistance to shock and vibration. Write for further information today.

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Silvered for maximum conductivity — contact resistance 0.005 ohms maximum.

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Designed for interchangeability — fits existing holders with .156 diameter solid prongs or .135 minimum diameter Banana pins on ¾" centers (such as Signal Corps Types DC-34, DC-35 and FT-171-B).

LOW LOSS

Socket casting is molded from low-loss, mica-filled phenolic (as per Joint Army-Navy Spec. JAN-P-14, type designation E-4)

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Approximately 4 weeks from receipt of order.

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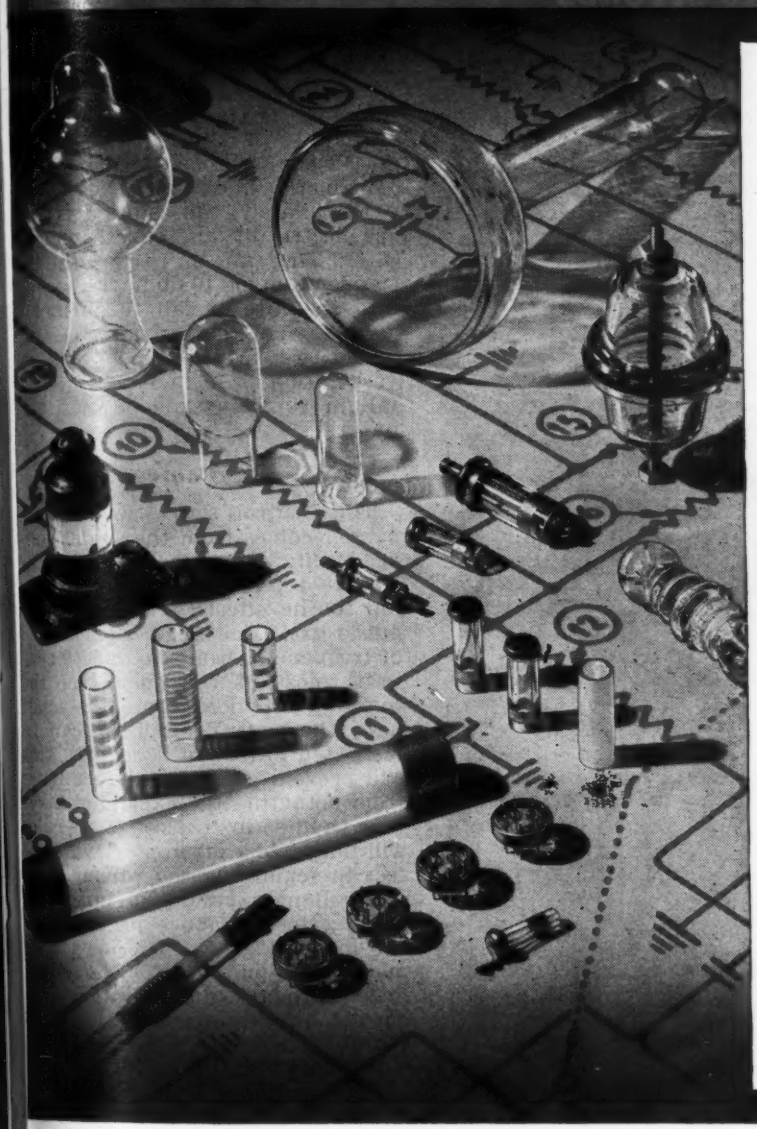

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High dielectric strength — high resistivity—low power factor—wide range of dielectric constants—low losses at all frequencies.

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AS YOU plan post-war electronic products, give a thought to versatile glass. We really mean glasses, for Corning has, at its fingertips, 25,000 different glass formulae from which to select those especially suited to your electronic applications. Let us show what glass can do for you. We may already have a solution — or Corning Research can find the answer for you. Address Electronic Sales Dept., [illegible] Bulb and Tubing Division, Corning Glass Works, Corning, New York.

CORNING *means* Research in Glass

Electronic Glassware

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THERMOSTATIC METAL TYPE

DELAY RELAYS

PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

Other important features include:—

1. Compensated for ambient temperature changes from —40° to 110°F.
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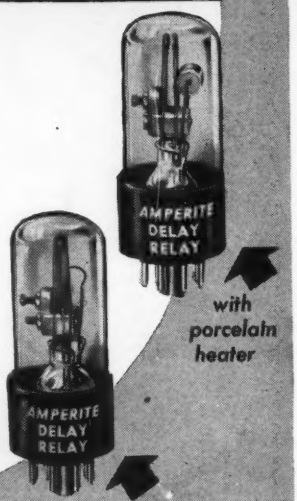

with porcelain heater

with heater wound directly on blade

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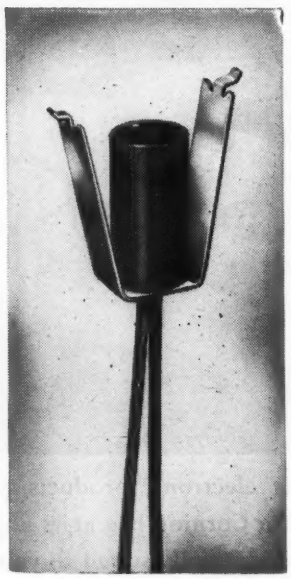
In Canada: Atlas Radio Corp., Ltd. 560 King St. W., Toronto

Check the Quality Features of the Drake No. 500 Series

- Time tested — *Millions have been used Since March 1940!*
- Available in *any* quantity with *any* type of bracket.
- Sturdy Bakelite Molded insulating casting shields socket from outside contact.
- Center contact lead wire mechanically secured before soldering.
- Both lead wires withstand over 25 lbs. tension.
- Rounded eyelet edges prevent cut or frayed lead wire insulation.
- 1000 volts minimum breakdown voltage between contacts and to ground.
- Casting mechanically secured to bracket — can't turn.
- Socket mechanically secured within casting — can't turn or be pulled out.
- Center contact secured within socket — contact won't protrude when lamp is removed.



The NO. 527F TYPE

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Consider this better underwriters' approved DRAKE dial light assembly for war or peace-time products. Lead wire 2¾ in. to 4 ft. Prompt shipment in any quantity assured. May we send samples or our newest catalog?

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DRAKE MANUFACTURING CO.

1713 WEST HUBBARD ST., CHICAGO 22, U. S. A.

IMPROVING RECORDINGS

(*Continued from page* 84)

produce unpleasant "jumps" in the volume of the music. It has been found that for most music 10 db is a maximum safe value.

The manner in which the expansion takes effect is also important. When a sudden loud chord is played the expansion must be so rapid that no time lag in the rise of gain of the amplifier can be noticed. A rise time of one millisecond will be so small as to be unnoticeable. However, if the decay time is as rapid as the rise time, individual cycles of all frequencies below 1000 cycles will be expanded, with horrible results.

Fortunately, the solution is simple electrically, and effective musically. The rate of rise of the expander is made 10 db in .001 second, and the rate of fall 10 db in one second. This corresponds to what would be heard in a room with reverberation. In fact, a too-rapid fall in volume would be most unnatural.

Control amplifier

The control signal for the expander comes from the signal voltage itself. It is necessary that the volume level be regulated according to the effective volume of the music itself. Inasmuch as the band of frequencies from 200 to 3000 contains most of the energy of the sound which determines the loudness, the control amplifier can be restricted to these frequencies. This will prevent excessive surface noise from actuating the expander. Likewise thumps in the low frequencies will not have a disproportionate effect in regulating the volume.

A volume expander designed according to the above principles is shown in Fig. 1. The device is made push-pull in order to minimize harmonic distortion, and to obviate filtering of the grid control signal. Any filter in the grid circuit would introduce objectionable time delay. If this controlled stage is used in a push-pull amplifier an output transformer is unnecessary. However, if it is desired to insert the amplifier in a single-ended amplifier it will be necessary to use a transformer output. For this purpose a good single plate to push-pull grids transformer can be used. The grid windings are used to supply the plates of the 6K7 tubes, and the primary, (10,000 ohms or so) suitably terminated with a load resistor, will give single-ended output.

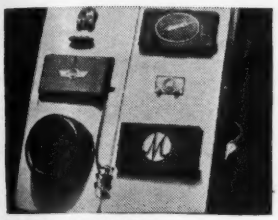
The frequency response of this expander can be made as good as any other resistance-coupled amplifier. The frequency response of the control amplifier is shown in Fig. 2.

(*Continued on page* 210)

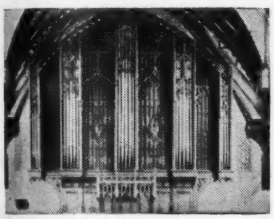
B-L METALLIC RECTIFIERS SINCE 1927

SELENIUM COPPER SULPHIDE

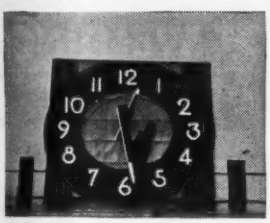
A few B-L Rectifier applications are illustrated below:



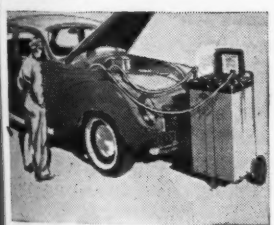
AUTO RADIOS



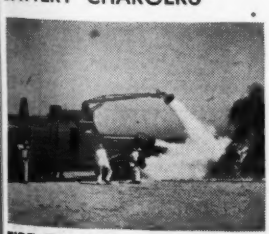
PIPE ORGANS



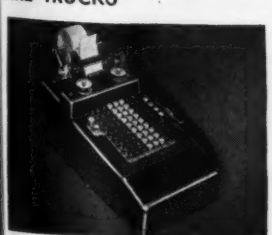
CLOCKS



BATTERY CHARGERS

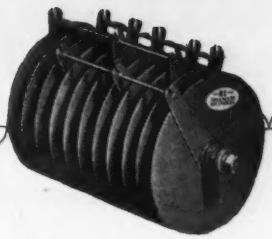


FIRE TRUCKS



BUSINESS MACHINES

from AC →



→ to DC

B-L METALLIC ELECTRICAL RECTIFIERS (SELENIUM COPPER SULPHIDE)

offer you these advantages:

***They are* COMPACT**

For a given power output the space required by metallic rectifiers is very small.

***They are* SILENT**

B-L Rectifiers are silent in operation and have no moving parts.

***They are* DEPENDABLE**

Dependability is assured by their simple and rugged construction, in which no glass bulbs, filaments, or other fragile parts are employed.

***They are* TROUBLE-FREE**

Regular maintenance and attention are unnecessary.

***They are* RUGGED**

B-L Rectifiers are rugged and will withstand heavy overloads for short periods of time.

***They are* ADAPTABLE**

B-L Rectifiers are adaptable for power outputs from Milliwatts to Kilowatts.

Many rectifier applications, heretofore considered impractical, have been devised by B-L Engineers. It is more than likely that they can be of assistance in solving your problems of converting AC current to DC... Write for Copper-Sulphide Bulletin R38-b — or for Selenium Bulletin R41-b.

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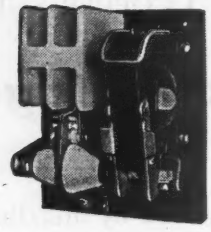
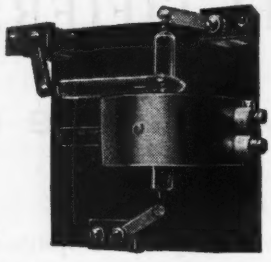
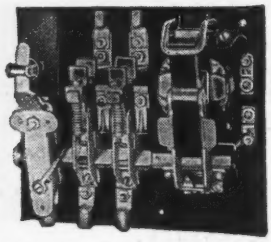
SWITCHING APPARATUS
FOR ELECTRONIC EQUIPMENT

Shown below are just a few of many specialized types of switching apparatus which we design and manufacture specifically for electronic application. If you are confronted with an unusually difficult switching problem, write, and we'll be glad to consult with you regarding your requirements.

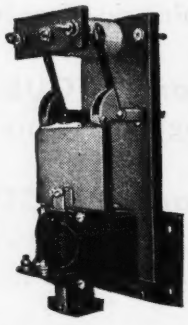




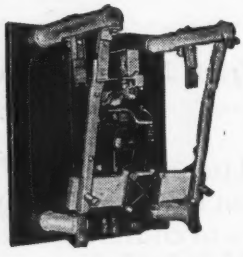
HIGH VOLTAGE D. C. HOT BREAK CONTACTORS for energizing high voltage vacuum tube circuits. Contactor, *above left,* breaks circuit carrying 1 ampere at 3,000 volts D. C. Contactor, *above right,* successfully breaks circuit carrying 2 amperes at 5,000 volts because contacts operate in a vacuum. This contactor incorporates principles of Eimac VS2 vacuum switch which eliminates external moving parts. Operating coil completely shielded. Can be completely tropicalized.



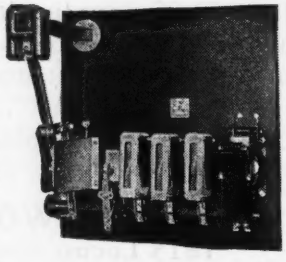
CONTACTOR-TIMERS used as main power or filament contactors with auxiliary delayed time circuit or circuits. Contactor and timer joined together physically, as well as electrically, saving space, assuring certain operation.



HIGH VOLTAGE-HIGH FREQUENCY CONTACTORS designed primarily for high frequency switching from a remote control point. Can be used with any high voltage cold break application—A. C. or D. C. All insulation of low loss type, either steatite or glass bonded mica. Held either mechanically or magnetically. Furnished either normally open, normally closed or both. Our complete line of contactors range from 15 amps at 3,000 volt minimum to 35 amps at 25,000 volt maximum.



HIGH FREQUENCY-HIGH VOLTAGE TRANSFER SWITCHES for either radio or industrial load transfer. Magnetically operated from remote point but mechanically held in either position. Can accommodate currents up to 75 amps high frequency. Insulation of low loss type, either steatite or glass bonded mica. Cold break only.



COMBINATION POWER AND SIMULTANEOUS CONDENSER DISCHARGE CONTACTOR, right, is a striking example of Monitor's ability to create highly specialized switching apparatus designed in accordance with unusual customer specifications.

Consult us on all of your switching requirements. Remember, we specialize in doing the unusual.

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Monitor — The Original Press Button Starter

SPOT WELDIN
with a PAIR of
TWEEZERS..
Remarkable

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- Probes For, Bends, Holds, Welds Small Parts
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Already performing successfully for some of America's leading manufacturers, welding fine wires .003" OD and larger. Applications unlimited. Send along problems and samples for quick solution in our testing laboratory.

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To Our Friends and Customers

The Langevin Company Inc. believes its customers are entitled to a statement of the company's future plans. The entire life of the company has been spent in the audio frequency field. *It intends to remain in that field.*

Due to its war effort, its facilities, experience and personnel have been increased. It will continue to develop, design and manufacture—to better than FM standards—sound and broadcast speech input equipment.

Its products will continue to include quality transformers and quality amplifiers, ranging from the smallest unit to especially-engineered speech input systems for the large broadcast stations. Much of this equipment is now in production; some in development—some between development and production.

To our old customers, the above is sufficient. To those who may be interested in becoming customers—we are 23 years old, all our equipment carries the Union Label and is fully licensed under A.T.&T. patents.

Paul S. Langevin
PRESIDENT

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INCORPORATED
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SENSATIONAL VACUUM TUBE VOLTMETER PROBE DEVELOPMENT

Radically Improved

High Frequency Performance

½ MICROMICROFARAD INPUT CAPACITY

OVER 1,000,000 OHMS INPUT RESISTANCE AT 200 MEGACYCLES

Interchangeable with Standard VM-27 Probe without Recalibration

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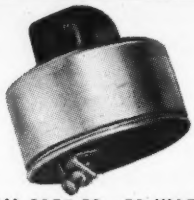
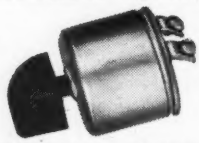
AN 3155 POWER RHEOSTAT



AN 3155-50—50 WATT



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Totally enclosed in accordance with Army-Navy specifications (AN-R-14A).

Permanently sealed in dust-proof, corrosion-proof metal cases.

Smooth control, rugged and thoroughly dependable under the most severe service conditions—shock, vibration, humidity, heat, cold, and altitude.

Hardwick, Hindle is proud of the excellent performance of these power rheostats on thousands of planes flying in every theatre of war under all climatic conditions. And they will prove to be invaluable in innumerable post-war applications.

Let us send you technical data and detailed information on these and many other rheostats and resistors with H-H exclusive features.

Write today for our new catalogue.

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RHEOSTATS and RESISTORS

SUBSIDIARY OF

THE NATIONAL LOCK WASHER COMPANY

ESTABLISHED 1886

Newark 5, N. J., U. S. A.

IMPROVING RECORDINGS

(*Continued from page* 206)

The meter which is in the plate supply lead to the controlled stage gives an indication of the expansion at any instant. This meter should be of the volume-indicator type of movement, because an ordinary milliammeter would overshoot sudden changes in gain. If dynamic readings are not to be taken this special meter need not be used. Fig. 3 is the calibration of this meter in terms of amplifier gain. It can be seen that the range of volume expansion available depends on the initial plate current. The 500 ohm potentiometer shown in Fig. 1 adjusts the fixed bias on the grids of the control stage.

Fig. 4 shows the expansion characteristics for several values of initial bias. The absolute level at which expansion begins depends on the gain of the control amplifier channel. Obviously, at high settings of the expansion control the input level required to actuate the expander will be lower than at lower settings of the expansion control.

The use of full-wave rectification for the signal is important for smoothest operation of the device. Many complex waves have positive and negative peaks of considerably different values. With a half-wave rectifier the phasing of the input signal would make a great difference in the amount of control voltage developed.

The 2 Meg. resistor and .25 μfd capacitor at the rectifier output determine the release time of the expander. The values given produce good results with most types of music. For very slow music it might be desired to increase the time constant. This can be done by increasing the value of the resistor. This resistor can, of course, be made variable. If variable time delay is desired a resistance variable from one to 10 megohms will give all the values desired.

Volume expander

The operation of the volume expander to produce satisfying results requires some care. Music in which the contrast between loud and soft is a very important factor benefits most by volume expansion. Such music is any of the Rossini overtures (especially as recorded by Arturo Toscanini), Tschaikowsky Symphonies and Fantasias, orchestral music of Wagner and Strauss and other music of a dramatic nature.

The expander should not be used with any vocal music, string quartets or other music where the volume range would be less than 20 db in the actual performance. In fact in any record of any type

(*Continued on page* 214)

FARNSWORTH

EXTENDS COMMUNICATION ACTIVITIES

BY ACQUIRING

THE HALSTEAD

TRAFFIC COMMUNICATIONS CORPORATION

WILLIAM S. HALSTEAD, president of the Halstead Company, joins the Farnsworth organization as consultant on radio communications equipment and traffic control, as well as on other phases of Farnsworth's broad electronic developments.

JOHN A. CURTIS, vice president of the Halstead Company and chairman of its management committee, joins the Farnsworth organization as manager of the mobile communications division.

To EXTEND its broad communications activities into the rapidly expanding field of mobile railway and highway communications and control, Farnsworth has acquired the assets of the Halstead Traffic Communications Corporation, including its developments, designs and patents. Key personnel, including William S. Halstead, president, and John A. Curtis, vice president, have joined the Farnsworth staff.

The Halstead organization is a recognized pioneer in this relatively new field of radio communications. It has invented, developed and produced field-tested equipment to provide railroads with modern, unfailing radio communications. It gave the world its first successful highway radio service, including the centralized control of busses, trucks and passenger vehicles.

The Halstead technical staff will establish new headquarters at the Fort Wayne Farnsworth laboratories. The organization will be merged and coordinated with more than two hundred Farnsworth research and development engineering personnel—a staff of scientists and technicians recognized as one of the country's leading technical organizations in the development of television; broadcast transmitters and receivers; radio-phonographs, and the most complicated types of radio and radar equipment for the Armed Forces.

Farnsworth resources, plus its seventeen years of electronic pioneering, its extensive engineering staff, and specialized manufacturing facilities, will strongly augment the outstanding position of the Halstead developments in this field.

FARNSWORTH TELEVISION & RADIO CORPORATION

FORT WAYNE 1, INDIANA

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Control Systems for Rail and Highway • the Farnsworth Phonograph-Radio • the Capehart • the Capehart-Panamuse

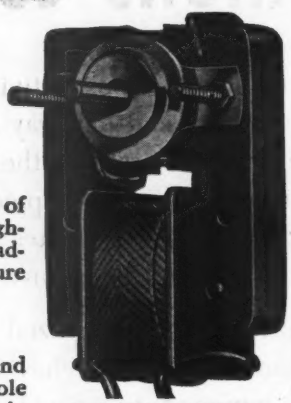
1,001 USES

Condensed Power for Years of Service

VERSATILITY and dependability were paramount when *Alliance* designed these efficient motors—*Multum in Parvo!* . . . They are ideal for operating fans, movie projectors, light home appliances, toys, switches, motion displays, control systems and many other applications . . . providing economical condensed power for years of service.

Alliance Precision

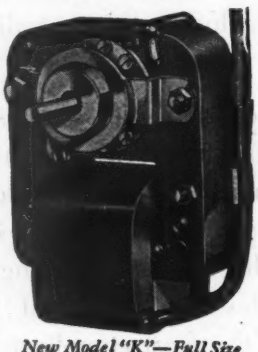
Our long established standards of precision manufacturing from highest grade materials are strictly adhered to in these models to insure long life without breakdowns.



Model "MS"—Full Size Motor Measures 1¾" x 2 x 3⅛"

EFFICIENT

Both the new Model "K" Motor and the Model "MS" are the shaded pole induction type—the last word in efficient small motor design. They can be produced in all standard voltages and frequencies with actual measured power outputs ranging upwards to 1/100 H. P. . . Alliance motors also can be furnished, in quantity, with variations to adapt them to specific applications.



New Model "K"—Full Size Motor Measures 2⅛" x 2⅜" x 3 1/16"

DEPENDABLE

Both these models uphold the *Alliance* reputation for all 'round dependability. In the busy post-war period, there will be many "spots" where these Miniature Power Plants will fit requirements . . Write now for further information.

Remember Alliance!
—YOUR ALLY IN WAR AS IN PEACE

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ARE *Big* PRODUCTS

— big in their importance to the manufacture of precision instruments, for they are the *almost infinitesimal* screws that are used in the assemblies of many of the world's finest mechanical masterpieces.

For more than half a century Waltham has specialized in the production of *precision* screws. Its plant and equipment have steadily modernized and expanded to meet the demands of every period of business development and the exacting needs of three wars.

Waltham is tooled to produce fine screw machine products *for a million uses*—any thread, material or finish — any type head, from 1/64" to 1½" diameter.

America's Outstanding Producers of Fine Instrument Screws

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WALTHAM SCREW COMPANY

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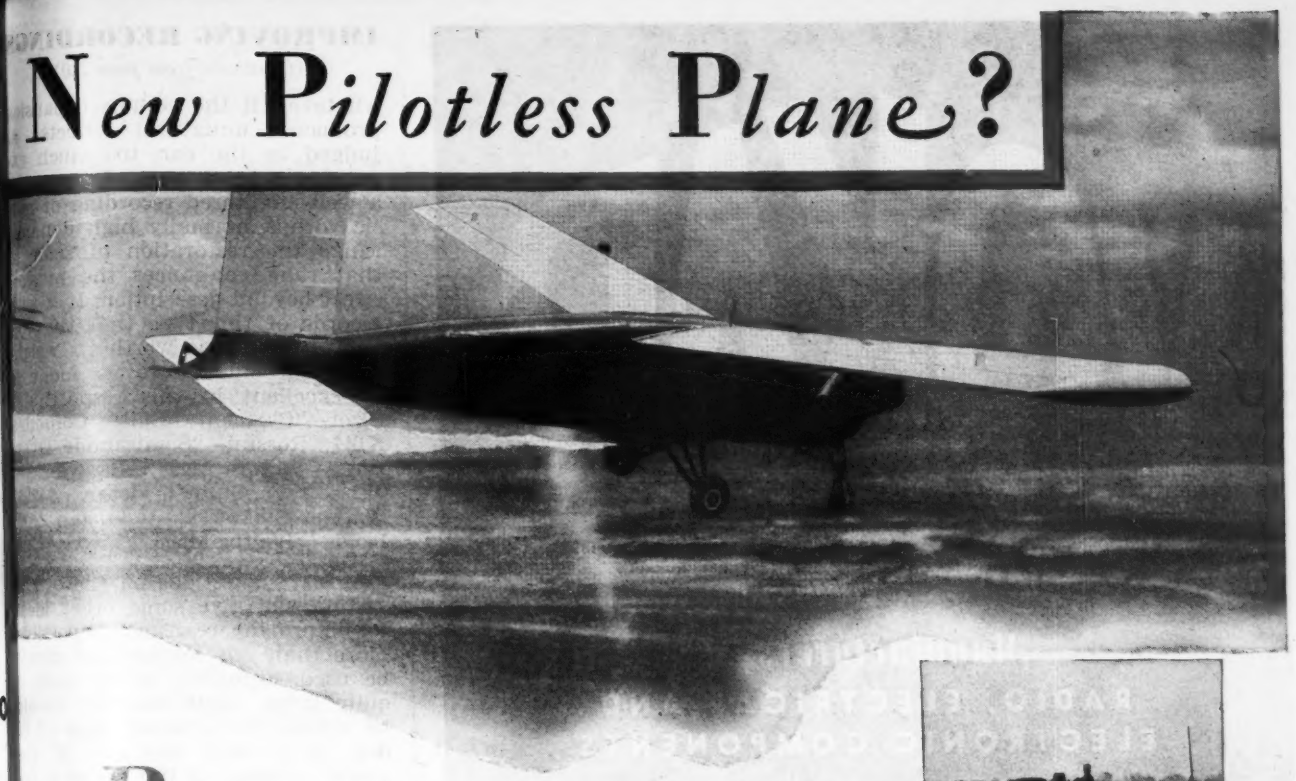
New Pilotless Plane?



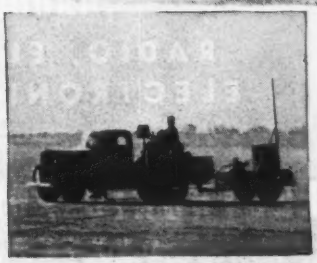
BACK IN 1939 PACIFIC DIVISION HAD ALREADY FLOWN THIS RADIO CONTROLLED AIRPLANE

Six years ago we did it the hard way. Month after month at an isolated camp in the Mojave Desert Pacific Division radio engineers collaborated with Lockheed engineers to perfect electronic controls and the aerodynamic characteristics of one of the first airplanes to fly by radio direction alone.

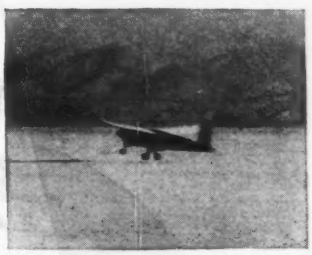
The operations were part of a special Army project and, in all, six airplanes of Lockheed design were successfully flown. In light of the tremendous strides Pacific Division radio engineers have made since those early days, it is interesting to know that this first radio control receiver had to provide simultaneous operations of *thirteen* controls—for the elevator, rudder, 5-position throttle, altitude, airspeed, counter, camera and parachute release.

The success of these early, complicated experiments have given Pacific Division a six-year lead in the development of numerous types of VHF control and communication equipment. We would like the opportunity to demonstrate how these modern controls may solve your problems, too.

© 1945, Bendix Aviation Corp.



This portable 100 watt transmitter was used to control the plane. "Ground Pilot" sat in the truck body.



Taken from movie film, this shows an actual take off. Note perfect flight attitude for this critical operation.

Trailing smoke made observation easier. The 80 h.p. plane, comparable to a single-seater, had speed of 105 m.p.h.

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IMPROVING RECORDINGS

(*Continued from page* 210)

whatever, if the volume expansion produces unnatural effects as judged by the ear, too much expansion is being used. However, on a well-monitored recording of music with a normally high dynamic range the restoration of some of that range enhances the musical effect beyond description. It is with records of this type that the volume expander is worth its weight in gold. Some recordings found to be excellent in this respect are: Bizet—"Carmen" Suite—Columbia X144; Rossini—"Semiramide Overture"—Victor M408; Stravinsky—"Firebird Suite"—Victor M291; Wagner-Stokowski—"Tristan and Isolde"—Victor M508.

A few suggestions on the overall system will give some other ideas for improving realism. If possible more than one loudspeaker should be used, especially if the room is quite large. Both speakers should be within an included angle of 90 deg. from any listener. If the sound arriving at the ear of a listener is very obviously from two separate sources, the mind refuses to blend them into a satisfying "wave front" of sound. Extremely effective results can be obtained in a good sized room of rectangular shape. In this case the loudspeakers should be placed in adjacent corners at one end of the room. The listeners should be placed as far from the loudspeakers as possible and approximately equidistant from both speakers.

If one of the speakers is supplied with frequencies from about 500 cycles down and the other with frequencies from about 500 cycles up the utmost in realism is accomplished. A close approach to the stereophonic sound system is produced in this way. Listeners will feel that the orchestra is spread out across the end of the room and the feeling of "presence" will be uncanny.

Successful reproduction of music resolves itself into the careful adjustment of all components in the system, with an eye to the effect each has on each element of the musical performance.

INCENTIVE PAY

(*Continued from page* 86)

and the company would pay royalties through this pool to its own employees during their continued employment with the company.

5. No straight salary would be provided. Instead, a total percentage of sales would be fixedly allocated to "engineering compen-

(*Continued on page* 218)

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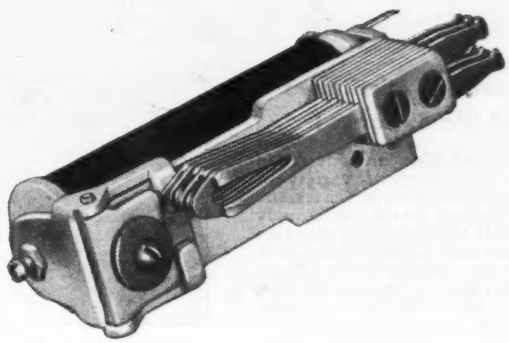

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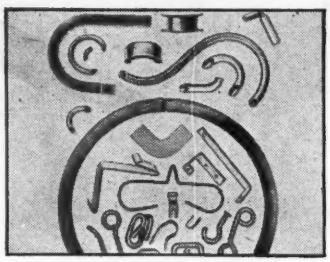
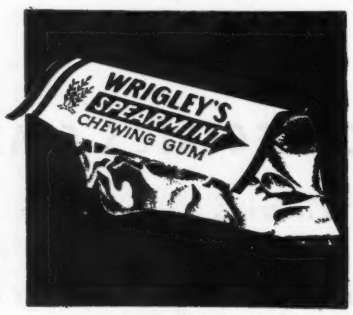


Typical Shapes Formed by the DI-ACRO Bender



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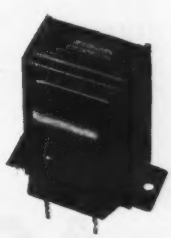

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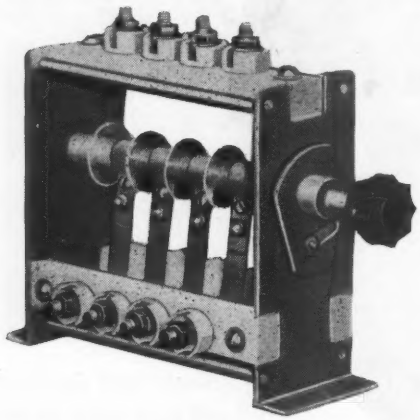

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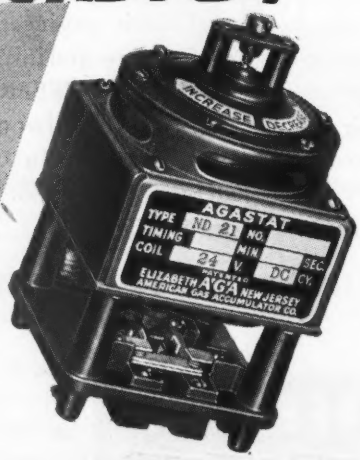

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INCENTIVE PAY

(*Continued from page* 214)

sation." This percentage could be subdivided into research, development and production segments. The share of each man could be predetermined much in the way law and investment securities partnerships operate. In other words, the engineering department would function as a partnership whose income fluctuated with the business of the company. This idea could be modified by a guarantee of salary, drawing account, sliding scale or "power" increment tied into company profits. After all, manufacturers' representatives have waxed fat on these kinds of deals during recent years—at the expense of engineers who do most of their selling for them.

6. One or more of the above ideas, except that the overriding compensation would be paid in company stock. This gives a double-barrelled incentive and while more adaptable to the medium-sized company is an extremely effective approach.

Engineer's requirements

The above six suggestions are a few out of many that could be proposed. Basically, I feel three things should be done:

A. The engineer should have security and a stable income.

B. He must then prosper as the company grows; and

C. He must have special recognition for signal achievements.

The sooner our electronic companies realize the power behind plans such as these and the extremely interesting results that can come from new thinking, the sooner the engineer can emerge and be proud of his profession.

Has a salesman or a movie director more "on the ball" than an engineer? I don't believe it—but right now the income tax man does.

Maybe the amusement industry grease-paint idols deserve what sound pictures have given them. I wonder what proportion the **total** engineering **payroll cost** of "sound on film" bears to **annual** salary costs of directors and "stars." Or how broadcast engineering cost is related to annual "talent" and program outlay. Just think it over! I contend that our engineers made possible sound pictures and radio, just as they will television and a host of other things.

Can't we pick out one of the proposals in the foregoing—change it around some, if we must—and get started recognizing that the fundamentals of electronic development are in the laboratory design room and factory, and not in exploitation? There's no time like NOW.

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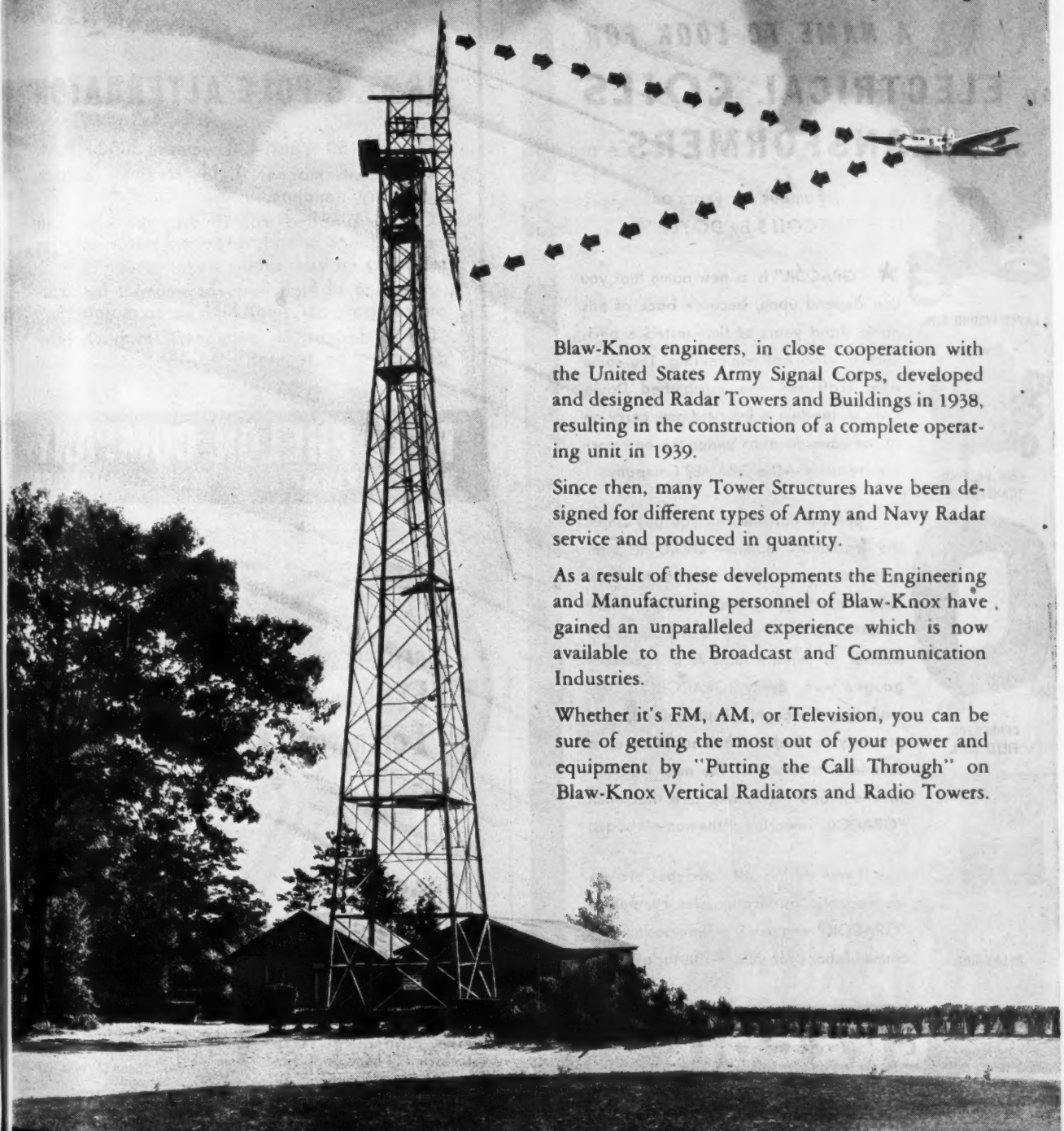
is not new to the Blaw-Knox Company



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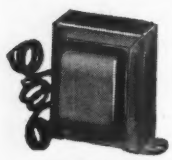
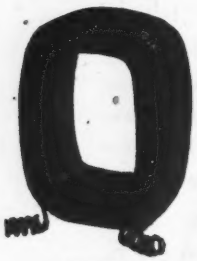


LOW VOLTAGE TRANSFORMER



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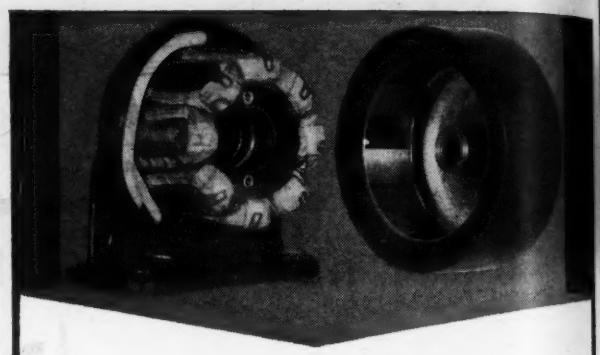

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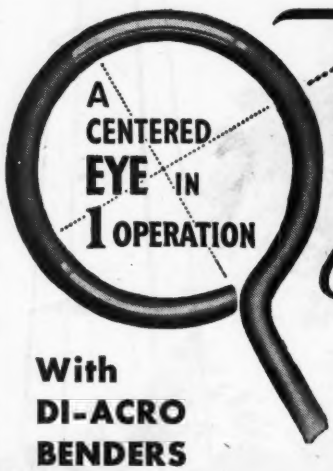

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INSTRUMENT TUBING—In this field, Superior furnishes hypodermic needle tubing, metal tubing for surgical instruments and parts, pointer tubing for electrical instruments, flattened tubing for Bourdon Springs. The hypodermic needle tubing is available in all standard sizes in the temper developed over a period of years, as most suitable for the application. The pointer tubing is generally aluminum where you get the combination of extreme lightness and maximum strength. For Bourdon Springs, Superior uses SAE 4130 X and Beryllium Copper.

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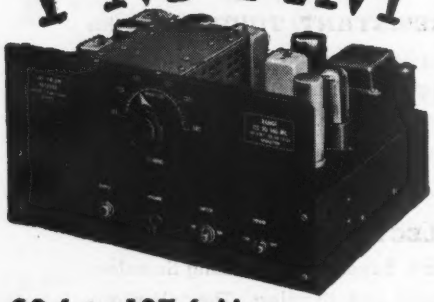

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ANTENNA GAIN

(*Continued from page* 89)

Suppose that we can adjust the transmitter power so that the minimum voltage on the measuring section with either the directional antenna or reference antenna connected has the same value, then:

$$\frac{P_D}{P_R} = \frac{q_D}{q_R} \tag{8}$$

where q_D and q_R are respectively the standing wave ratios when directive antenna and reference dipole are connected.

And the corrected antenna field gain is

$$(AFG)_2 = (AFG)_1 + 10 \log \frac{q_D}{q_R} \tag{9}$$

$10 \log \frac{q_D}{q_R}$ versus $\frac{q_D}{q_R}$ is plotted in Fig. 4.

Feeder attenuation

The total attenuation of the feeder with standing wave ratio q is larger than the total attenuation of the same feeder when matched to the load. This follows from the fact that the lack of matching introduces the reflected waves which produce the additional losses. Averaging the losses occurring in the feeder element over its total length, it can be shown* that the effective attenuation A_{eff} is approximately:

$$A_{eff} = .5A\left(q + \frac{1}{q}\right) \tag{10}$$

where

$$A = \alpha L \tag{11}$$

and

α—attenuation constant (in db per 1000 feet)

L—length of feeder (in thousands of feet)

A_{eff}/A versus q is shown in Fig. 5.

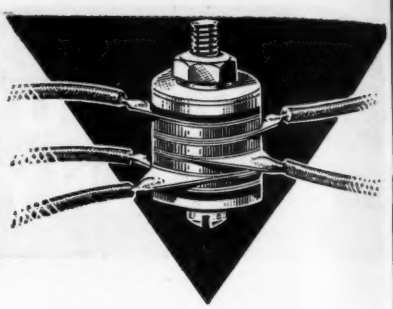
Antenna gain

If $(A_{eff})_D$ and $(A_{eff})_R$ are respectively the effective attenuations when directional antenna and reference dipole are connected, then the gain $(AFG)_3$, corrected for the constant power input to the antenna is:

$$(AFG)_3 = (AFG)_2 + A\left[\frac{(A_{eff})_D}{A} - \frac{(A_{eff})_R}{A}\right] \tag{12}$$

To show the importance of the

*Proc. I.R.E.



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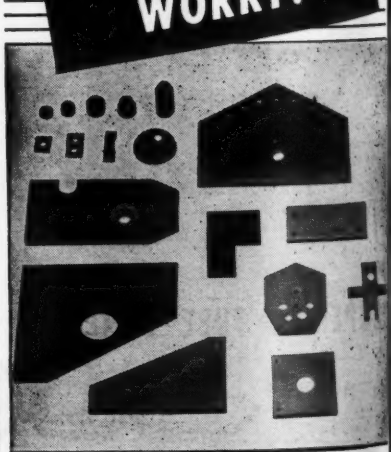

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corrections discussed let us calculate the following example: If $\frac{E_D}{E_R} = 2.5$, $q_D = 1.8$, $q_R = 1.2$, $A = 4$db., then $(AFG)_1 = 8$ db.

$$(AFG)_2 = 8 \text{ db.} + 10 \log \frac{1.8}{1.2}$$

$$= 9.8 \text{ db.}$$

$$(AFG)_3 = 9.8 \text{ db.} + 4(1.19 - 1.02) = 9.8 \text{ db.} + .68 \text{ db.} = 10.48 \text{ db.}$$

This shows how simple the application of the transmission line measuring technique is for the accurate measurement of the directive antenna field gain.

RCA'S ANTENNALYZER

An electronic "brain," called the Antennalyzer, which in the space of a few minutes solves with complete accuracy the complicated problems of directional antenna design that heretofore have required weeks of laborious computation, was described in Washington, on September 10 by Dr. George H. Brown, of RCA Laboratories, Princeton, N. J., speaking before a section meeting of the Institute of Radio Engineers.

Radiation patterns

Directional antennas for broadcast stations must be designed and erected to protect the service areas of existing stations on the same or adjacent channels, Dr. Brown said. But although the proper design formulas are known, he explained, their solutions have been based on the use of trial values which in the final analysis often resulted in no more than close approximations. The Antennalyzer eliminates these inaccuracies.

(*Continued on page* 226)

RCA's Antennalyzer is an electronic computing device which automatically solves the problems of locating and arranging new antennas. Readings taken from dial settings indicate proper tower location to direct maximum power where wanted

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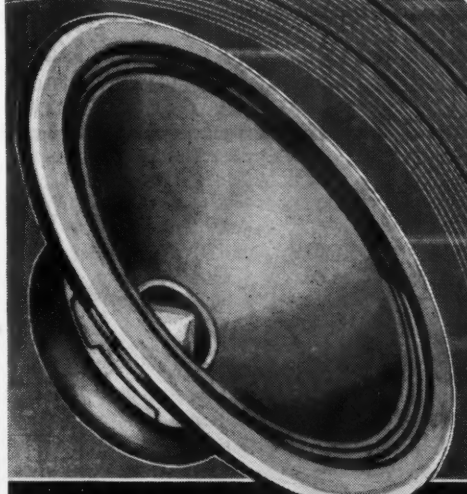

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Electrical Characteristics —

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WIRE-WOUND RESISTORS

SPRAGUE ELECTRIC COMPANY, Resistor Division, North Adams, Mass.

RCA'S ANTENNALYZER

(*Continued from page 223*)

The RCA Antennalyzer, Dr. Brown said, consists of a number of interrelated circuits whose electrical values may be adjusted by dials. Knowing the desired directional pattern of the projected broadcast station, the operator twiddles the 16 dials and observes the results on a cathode ray oscillograph. When the curve of the graph corresponds to the required directional pattern, the dial settings are recorded. These figures tell where to locate the antenna towers, and give the current ratios and phase angles to use in designing the system as a whole.

Analyzer operation

In operation the Antennalyzer utilizes a radio frequency signal obtained from a crystal controlled oscillator. This signal is then divided into five distinct channels, each channel representing one antenna element of the directional array. By manipulating the dials, an operator can vary the amplitude and phase of each channel as desired.

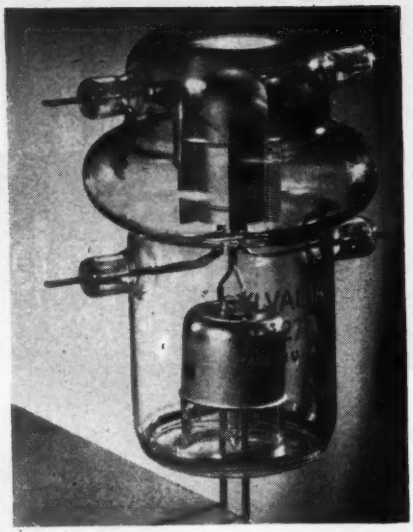
General principles of the Antennalyzer, Dr. Brown pointed out, were worked out on paper several years ago but construction of the first unit was delayed while a search was made for a superior phase modulator. A crystal-controlled phase modulation system developed by R. D. Kell of the RCA Laboratories, for another purpose, was found to be ideal for the Antennalyzer.

The Kell circuit makes it possible to phase-modulate each channel with a total swing of 720° plus and minus. The Antennalyzer uses 52 vacuum tubes in addition to the 26 tubes comprising the special cathode ray oscillograph and its attendant amplifiers.

Five tower arrays

In performing its computations electronically, "the Antennalyzer," Dr. Brown said, "adds and subtracts angles, multiplies, looks up trigonometric functions, adds numbers together, squares them and finally takes the square root of the whole." Because individual values represented by the dial settings are highly accurate, the final result is equally accurate and there are no compromises involved as in former slide-rule-design procedure.

The Antennalyzer, Dr. Brown said, is limited to the design of directional arrays up to five towers. This, he asserted, will take care of almost any directional antenna problem that will arise for years. When needed, however, additional circuits to compute data for a larger number of towers could be added, practically without limit.



Power Measurement

Simple, direct measurement of the power output of electronic and radio communication equipments at frequencies up to 900 mc. are provided by six types of power measurement lamps developed by Sylvania Electric Products Inc., Emporium, Pa. Built with two identical small filaments and mounted in lock-in type bases, these lamps measure power outputs ranging between 0.05 and 25 watts with accuracies within 5 per cent or less, depending on the type of reading taken. Power output measurements are made by connecting one filament to the high frequency output and the other to an ac or dc source. Voltage of the second filament is regulated until both filaments are equally bright. Power is determined by meter readings in the ac or dc circuit with equal power dissipated by the filament in the high frequency circuit.

New Oscillating Crystals

The Department of Commerce reports that an electrical equipment manufacturer in Switzerland is using potassium - hydrophosphate as a substitute for natural quartz crystals in radio transmission sets. The process for making the artificial crystals is said to be relatively simple as they can be cut into any required sizes.

Another substitute is suggested by C. P. Fagan, A.R.I.C., of Marconi's Wireless Telegraph Co., Ltd., in an article published in the August 1945 issue of Electronic Engineering, London. The following is taken from this paper:

"During an investigation of the tartrates, the writer found that lithium potassium tartrate was a crystalline compound with good electrical characteristics which could be obtained in large-sized crystals which had good mechanical strength, and which were not affected by atmospheric moisture. Such crystals are easily prepared by neutralizing a solution of potassium hydrogen tartrate with lithium hydroxide, and crystallizing the resultant solution. Small seed crystals may be obtained by allowing a portion of the solution to evaporate spontaneously. A seed crystal of suitable size, suspended by a hair or a very fine nickel wire in the saturated mother liquor, will grow quickly."

Physical features

"With regard to mechanical properties it may be said that the crystal is slightly less hard than Mycalex. Cutting and filing the crystal shows a tendency to cleaving in several directions, one normal to the principal axis. The crystal was not affected by atmospheric moisture over a period of twelve months. It was found that the piezo-electric axis coincided with the principal axis and no piezo-electric effects were observable in directions normal to this. One resonance was observed at 279 kc/s. Rough measurements showed that the 'Q' value was of the order of 2,000 in a circuit composing a heptode oscillator, requiring a series resonant impedance not greater than 0.1 megohm with the crystal standing vertically on one electrode with a top air gap of about .01 in. The fact that a crystal of such low 'Q' would oscillate in the above circuit indicates that the substance is of the order of ten times the piezo-electric activity of quartz. The frequency of resonance

$$f = 1{,}760/\sqrt{A},$$

where f is the frequency in kc/s, and A is the cross-sectional area in sq. mm. This would seem to indicate that the vibration is a simple expansion and contraction about the axis.

Temperature coefficient

"The indicated temperature - coefficient is — 426 parts in one million per + 1° C. As this value is more than 200 times the value usually permitted in medium precision quartz, it will be seen that the crystal is quite unsuitable as a frequency stabilizing element. While it is possible that a slant-cut crystal might have a zero coefficient, the angle of cutting would need to be very precise in order to obtain a good balance. Further experiments on lithium potassium tartrate crystals indicated that ageing effects are likely to be small, and that the substance is stable at all temperatures likely to be met with in normal apparatus in any part of the world. Breathing upon the crystal damps the oscillations, as with quartz, and it recovers as soon as the moisture has evaporated. While these crystals appear to be useless as frequency stabilizing elements the ease with which they can be prepared will be of interest to amateurs. Such crystals might be used as thermometers in a suitable holder, and might also be useful as a stable substitute for Rochelle salt."

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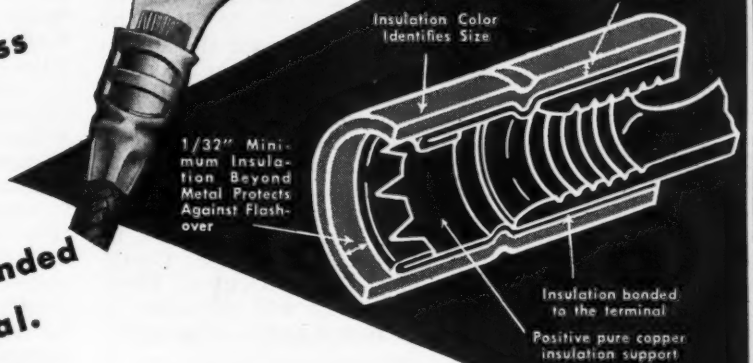
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Insulation bonded to the terminal
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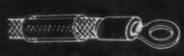

2 CRIMP TERMINAL TO WIRE

3 SLIDE TUBING OVER TERMINAL

REDUCED TO 1 QUICK OPERATION

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The AMP PRE-INSULATED TERMINAL

Providing Revolutionary speed and accuracy in mass production wiring with superlative electrical properties.

PERFORMANCE CHARACTERISTICS

1. Terminals withstand a temperature of 350 degrees for 10 hours without physical damage to insulation or any deleterious effects on insulation.

2. Minimum breakdown voltage is 2500 volts D.C. in air at sea level; 800 volts D.C. at altitude of 30,000 feet.

3. Insulation does not support combustion when tested in accordance with ASTM D350-40T.

4. Insulating qualities are unaffected by long immersion of terminals in 10 per cent salt solution.

5. Water absorption of insulation is less than 1½ per cent.

6. The pre-insulation takes the exact contour of the crimp without distortion or cracking. It will not dry out or come loose.

7. Maximum electrical and mechanical properties of the AMP "Diamond Grip" Insulation Support Crimp assure vibration-proof connections. All three crimps made in one operation by AMP hand tools or press dies.

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THE INSULATION IS PERMANENTLY BONDED TO THE BARREL OF THE TERMINAL. The AMP Pre-Insulated Terminal is delivered to you ready to install with AMP precision hand, foot or power installation tools — thereby eliminating all stocking and handling of separate sleeving, and eliminating costly human errors in its application. The cost of applying separate tubing to the terminal is approximately the same as the cost of applying the terminal itself to the wire.

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BOOK REVIEW

Electronic Laboratory Manual

By RALPH R. WRIGHT

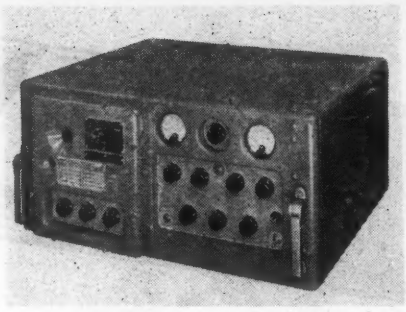
Published by McGraw-Hill Book Company, New York 18, N. Y.
First Edition, 77 Pages, 82 Illustrations
Price $1.00

This is a laboratory text book and manual for a first course in electronics for electrical engineering students. Twelve basic experiments are included concerned with the characteristics, with principles of operation and the application of electron tubes. Sufficient theory is included to provide the student with the background of each experiment to enable him to interpret and understand the results without additional guidance.

National UHF Receiver

Development of a radio receiver which in mechanical design is a revolutionary departure from existing types of construction has been completed by the National Radio Co. which has a $15,000,000 contract to supply the receivers to the Navy.

The receiver, which reaches into the ultra-high frequencies, is mounted on a drawer-slide, which does away with the necessity of removing the receiver from the cabinet. With the receiver pulled



out on this drawer-slide, the set can be tilted into three different positions so that all components can be reached easily.

Wilmotte's N. Y. Lab

Raymond M. Wilmotte, director of Wilmotte Laboratory, Inc., Washington, D. C., has opened a branch laboratory in New York City. The new laboratory is under the supervision of Paul H. Crago, former design engineer for the Union Switch and Signal Co., manufacturers of railroad signaling devices. He will be assisted by Hugh J. Cameron, formerly of the radio and radar division of the War Production Board, who will specialize in electronic heating, and G. Curtis Engel, formerly of General Electronics, Inc., who will specialize in electronic control and testing methods.

Ellis Joins Raytheon

Ray C. Ellis, former director of the WPB radio-radar division, has been appointed a vice-president of Raytheon Mfg. Co. From 1930 to 1941 he was with General Motors Corp. in various activities including engineering, sales, service, personnel and public relations, being associated with electronic work through most of this period. When General Motors entered the auto radio manufacturing business in 1936, Mr. Ellis was made general manager of the Delco Radio Division. In the spring of 1941, at the request of General Knudson, he joined O.P.M., later W.P.B., to start the mobilization of radio and radar production facilities

In 1942 he became director of the WPB radio and radar division. In addition to correlating the electronic production facilities in the United States, he made extensive trips to England and Russia, assisting those countries in the scheduling and production of their electronic equipment.

More recently, Mr. Ellis was chairman of an FEA Committee to suggest plans for the demobilization of the German electronic manufacturers and also was associated with Johns Hopkins University in the development and production of highly classified military apparatus.

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PERSONNEL

Harry A. Winne, vice president in charge of engineering for the General Electric Co.'s apparatus department, has been appointed vice president in charge of engineering policy for the entire company. **Ernest E. Johnson,** assistant engineer of the aeronautics and marine engineering division, has been named to succeed Mr. Winne. In assuming his new duties, Mr. Winne becomes a member of the president's staff. His headquarters will be in Schenectady. As chairman of the engineering council, Mr. Winne will co-ordinate the engineering, scientific, and research projects of all departments and all laboratories of the company. He will also be responsible for company policy and activities in connection with standards and the co-ordination of matters relating to recruiting, education, and transferring between company units of all engineering personnel.

Hugh S. Knowles, vice-president and chief engineer of the Jensen Radio Mfg. Co., Chicago, has been elected president of the Acoustical Society of America. He has been further recognized by the Fellowship Award of the Institute of Radio Engineers and the chairmanship of Committee on National Defense, Electroacoustics Standards of the IRE and Sound Equipment Standards of the RMA. He has also represented the IRE and RMA on various electroacoustical committees of the American Standards Association, and served as chairman of the Chicago Section of the IRE.

Mr. Knowles began his service with the Jensen company in 1931 as chief engineer and was elected in 1940 to the position of vice-president in charge of product research and development. He is inventor of many of the Jensen engineering innovations and heads a department of capable development and design engineers with that firm. Mr. Knowles is also an independent consultant in the electronic and acoustic fields.

Colonel George P. Dixon, who was chief of air communications for all United States air forces in the European theater of operations, has been elected a vice president of the International Telephone and Telegraph Corp.

Raymond C. Fancy, formerly with the radio engineering section of the Army Service Forces Headquarters, 6th Service Command, Chicago, has been appointed to head a new division of Barnes & Reinecke, industrial designers and engineers, Chicago. A member of the Institute of Radio Engineers, Mr. Fancy will be in charge of instruction manual and visual service aids production for Barnes & Reinecke.

Maxwell S. Symon has been appointed engineer-in-charge-of-sales for De Mornay-Budd, New York. He will handle all rf transmission equipment for radar, which the firm has been engaged in designing and manufacturing, as well as special navigational equipment for land, sea and air, the designing and engineering of which the firm has now entered.

Dominick Albanese has joined the staff of DeMornay-Budd, Inc., 475 Grand Concourse, New York, as a research engineer. He has just been released from the military services where he was a research engineer, is credited with the development of some 29 major developments for aircraft use.

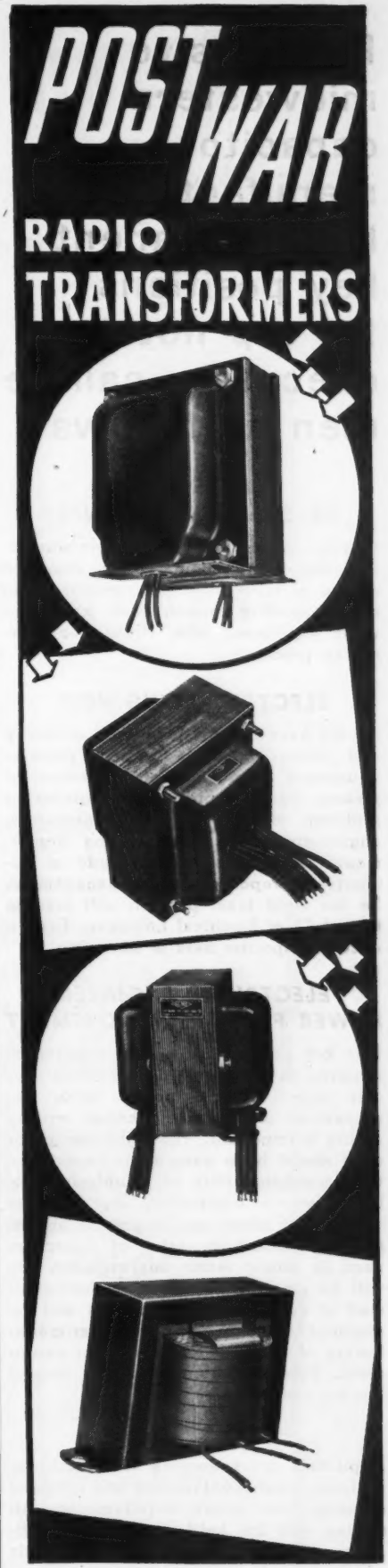
Carl P. Sorenson has been appointed consulting standards engineer for the Cherry Rivet Co., Los Angeles. He was formerly with the Glenn L. Martin Co., Baltimore.

William R. Hough, now product development engineer of the Reliance Electric and Engineering Co., Cleveland, has been appointed chief engineer of the company. He succeeds Fred E. Harrell who has been advanced to general works manager.

J. Harold Blair has been appointed sound communications engineer of Walker-Jimieson, Inc., Chicago. He goes to W-J from Operadio where he held the position of sales engineer.

F. F. Sylvester has been appointed technical director in charge of research and engineering for Reeves-Ely Laboratories, Inc., New York. Latterly with Lewyt Corp., Mr. Sylvester has had wide electronic experience, having been connected with Federal Telephone and Radio Corp., RCA, Hytron and other companies.

Arthur Slepian has been elected president of Universal Wire and Cable Co., Montreal. Until now he has been vice-president and general manager of Wheeler Insulated Wire Co., Bridgeport, Conn.



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NEW BULLETINS

Duplex Speakers

How 15 in., 25 watt duplex multicellular speakers increase area of horizontal and vertical sound distribution is explained and illustrated in a new booklet issued by Altec Lansing Corp., 250 West 57th St., New York 19, N. Y. Performance curves on and off axis are given. These show an extended useful range. Amplifiers of 15 to 18 watts output are also listed.

Resistors

A new resistor catalog of 32 pages has been issued by Ward Leonard Electric Co., Mt. Vernon, N. Y. The booklet describes and illustrates various types of units including vitreous, fixed or adjustable, plain ceramic, pressed steel cased and throughbolt styles. A line of ring type rheostats is also listed.

Engineering Training

A complete engineering graduate training course permitting exploration by the graduate engineer of production, sales, research, design, field work, administration and many other elements of industrial operation is outlined in a new training brochure, "Where Do We Go From Here," published by the Allis-Chalmers Mfg. Co., Milwaukee, Wis. Based on the theory that an engineer finds the right job by working at several, the two-year training course coordinates shop and office work in a program designed to fit individual aims and abilities.

Recently inaugurated, an Allis-Chalmers program of graduate study in cooperation with the Illinois Institute of Technology is also discussed. This program involves professional and technical education on the graduate school level, leading to a master's degree.

Locknuts and Fastgners

Stamped sheet metal locknuts are described and illustrated in a folder from the Palnut Co., 39 Cordier St., Irvington, N. J. Regular, inverted, acorn and washer types are available. Security against vibration as well as low cost are the object of the product.

X-ray Spectrometer

A new 12-page booklet, titled "Engineering - Design Development of X-ray Spectrometer," has been issued by North American Philips Co., Inc., 100 East 42nd St., New York. The text material covers in detail the basic design principles involved in the Geiger-Counter X-ray spectrometer — recently developed industrial control tool. Specifically, the author discusses: X-ray diffraction principles, new instrument requirements, X-ray source, pulse conditioning, frequency meter circuit, counting meter circuit, meters and controls, and applications.

Laminated Plastics

All the essential factual data and engineering information about Taylor phenol fibre, vulcanized fibre, and the new phenolastic fibre, as well as Taylor insulation (fish paper), Taylor silent gear material, special laminates, moldings, and assemblies are included in a new catalog of Taylor Fibre Co., Norristown, Pa. A section devoted to fabricating data contains the latest shop practices for machining laminated plastics and for servicing the tools and machines used in the many machining processes possible with laminated plastics.

Vacuum Capacitors

Specifications of vacuum capacitors from 6 to 100 mmfd. are included in a folder from Industrial and Commercial Electronics, Belmont, Calif. A patented method of external adjustment to precise values is featured, making possible accuracies to plus or minus 0.2 mmfd.

Drive-In Theaters

A detailed study of the construction and equipment of drive-in motion picture theaters has been issued by the Radio Corp. of America, RCA Victor division, Camden, N. J. Layout of ramps, type and location of projecting equipment, building construction required and reproducing equipment such as in-car speakers are all discussed. Also mentioned are methods of wiring the area for best control, drainage and surfacing problems and required illumination. There is a table showing the average temperatures for each month of the year throughout the United States with the higher temperatures emphasized to indicate the length of the available operating seasons.

Train Communication

Inductive type and space radio train communications systems and equipment are described and illustrated in a new brochure issued by the Aireon Mfg. Corp., 60 East 42nd St., New York. Numerous colored plates and simple explanations of the methods used and the advantages of each system are included. More detailed engineering explana-

(*Continued on page 233*)

1945 ELECTRONIC ENGINEERING DIRECTORY

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Fiber	14
Fiber-Glass	1
Field Coils	1
Field Exciters	1
Field Strength Meters	1
Filament Wire	1

ALPHABETICAL FINDING LIST of Electronic Manufacturers

Use this list if you know the name of a company and want to learn one of its products. Most of the following companies manufacture more than one product

A

Aarens Radio Corp., New York, N. Y.—Control Equipment
ABC Radio Labs., Indianapolis, Ind.—Antennas
Abbott Instrument, Inc., New York, N. Y.—Transmitters
Acadia Synthetic Products Div., Western Felt Works, Chicago, Ill.—Plastic Material
Accurate Spring Mfg. Co.—Springs

Airplane & Marine Instruments,, Inc., Clearfield, Pa.—Transmitters*
Air Reduction Sales Co., New York, N. Y.—Rare Gases
Air-Way Electric Appliance Corp., Toledo, Ohio—Motors
Ajax Electrothermic Corp., Ajax
Trenton, N. J.—Induct
Akron Porcelain

American Instrument Co., Silver Spring, Md.—Relays*
American Insulated Wire Co., Prov
R. I.—Wire
American

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LA

Antennas & Accessories

Airplane antenna	AA
All-wave (home)	AW
Antenna reeling equipment	AR
Auto	A
Dummy antenna	DA
Feeder spreaders	FS
Ground clamps	G
Grounding springs	GS
HF assemblies	HF
Insulators	I
Kits	K
Lightning arresters	L
Loop antennas	LA
Master systems	MS
Outlets	O
Rotary boam	RB
Television & FM	TL
Towers & Supports (home)	T

ABC Radio Laboratories, 3334 N. New Jersey St., Indianapolis, Indiana—AW
Acme Welding Co., Louisville, Ohio—AW, F, LA,T
Aeronautical Radio Mfg. Co., Roosevelt Field, Mineola, L. I., N. Y.—AA, I, LA, AR
Aircraft Accessories Corp., Fairfax & Funston Rd., Kansas City 15, Kan.—AA,LA
Airplane & Marine Instruments, Inc., Box 92, Clearfield, Pa.—TL, LA
The Akron Porcelain Co., Corey Ave., Akron 14, Ohio —I
Alpha Wire Corp., 50 Howard St., New York 13, N. Y. G, I, K, L, MS, TL
American Lava Corp., Cherokee Blvd., & Manufacturers Rd., Chattanooga 5, Tenn.—FS, I
American Radio Hardware Co., Inc., 478 Broadway, New York, N. Y.—G, O
Amplex Engineering, Inc., 1620 Grand Ave., New Castle, Ind.—RB, T
Amy, Aceves & King, Inc., 11 W. 42nd St., New York 18, N. Y.—MS, O
Andrew Co., 363 E. 75th St., Chicago, Ill.—AA, AW, A, HF, K, LA, MS, RB, TL
Astatic Corp., 830 Market St., Youngstown 1, Ohio—AA
Atlas Products Corp., 30 Rockefeller Plaza, New York

Centralab, D
Keefe Ave.
Clampipe—M
Collins Radi
Iowa—T.
Colonial Rad
—A
Communicat
Coral Gal
Communicat
Blvd., P
Consolidate
Chicago.
Cook Cera
N. J.—
Cook Elec
L
Corning
Cornish
T, N.
L, TL
Corwico
Coto-Co
R. I.
Creativ
N. Y
Doolitt
36,
DX Cr
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Eagle
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General Ceramics and Steatite
Keasbey, N. J.—FS, I
General Communications Co., 681 Beacon St., Boston
Ave., Bridgeport,

The Annual
DIRECTORY NUMBER
of
ELECTRONIC INDUSTRIES
December 1945

THE ONLY UPTODATE
RADIO-ELECTRONIC-TELEVISION
DIRECTORY TO BE PUBLISHED
IN THE LAST 18 MONTHS

Classified . . . Double-indexed . . . Complete

CALDWELL-CLEMENTS, INC.
480 Lexington Avenue, New York 17, N. Y.

HOW'S YOUR { *husband's* / *wife's* } I.Q.?

This little quiz lets you decide if you're doing your part to help Uncle Sam hold prices down. No thinking person wants a price inflation like the cruel one we had during and after the last war. That's why we have rationing, ceiling prices and wage controls this time.

		HE	SHE
Does { he / she } buy rationed goods without points?	*Never*	☐	☐
	Occasionally	☐	☐
	Often	☐	☐
Does { he / she } pay Black Market prices, forget about ceilings?	*Never*	☐	☐
	Occasionally	☐	☐
	Often	☐	☐
Does { he / she } buy a lot of things you don't really need?	*Never*	☐	☐
	Occasionally	☐	☐
	Often	☐	☐
Does { he / she } want to cash in a War Bond now and then?	*Never*	☐	☐
	Occasionally	☐	☐
	Often	☐	☐
Does { he / she } grab the first things back on the market— *when you could do without them a little longer?*	*Never*	☐	☐
	Occasionally	☐	☐
	Often	☐	☐
Does { he / she } believe in spending while the money's coming in easy, *laugh at you for trying to save up for a rainy day?*	*Never*	☐	☐
	Occasionally	☐	☐
	Often	☐	☐

HOW TO SCORE

Never counts 10, *Occasionally* 5, *Often* 0

If your husband's score is:

50 or Over—He's a wonder—hang on to him!

10-30—He's pretty good—steer him a little!

0-10—Get busy, lady—take him in hand!

If your wife's score is:

50 or Over—She's an angel. KISS her!

10-30—A word from you might be in order!

0-10—Only *one* thing to do SPANK her!

ONE PERSON CAN START IT!

You give inflation a boost

—when you buy anything you can do without

—when you buy above ceiling or without giving up stamps (Black Market!)

—when you ask more money for your services or the goods you sell.

SAVE YOUR MONEY. Buy and hold all the War Bonds you can afford—to pay for the war and protect your own future. Keep up your insurance.

HELP US KEEP PRICES DOWN

A United States War message prepared by the War Advertising Council; approved by the Office of War Information; and contributed by this magazine in cooperation with the Magazine Publishers of America.

NEW BULLETINS

(*Continued from page 230*)

tions are contained in a supplemental booklet in a pocket insert. For reasons of economy the use of space radio is advocated only for yard and head to rear communications and inductive equipment is recommended for main line and wayside station use.

Service Accessories

General Cement Mfg. Co., Rockford, Ill., has issued a catalog (No. 146) containing complete listings of the line of radio cements, chemicals, hardware, cabinet repair kits, repair parts, tools and other service accessories.

Cerium Alloys

Two lists of references to the uses of cerium as an alloying agent in conjunction with aluminum and magnesium have been compiled by the Cerium Metals Corp., 522 Fifth Avenue, New York. These annotated bibliographies have been selected from English, French and German material of the past twenty years. Patents are listed. Important articles are briefly summarized.

Generator Units

A line of electric generators up to 25 kw is described in a new catalogue of the Kato Engineering Co., Mankato, Minn. Gasoline-driven, hand-starting plants of 500 watts through 5,000 watts are listed in air cooled styles, and from 10 kw to 25 kw water cooled. Automatic controls are available. Independent generators, single and three phase, motor generator sets and high frequency generators are also featured. A group of high efficiency rotary converters and a dual voltage set are included.

Vitreous Resistors

Details of a line of vitreous resistors are given in a folder newly issued by Presto Electric Co. Inc., Union City, N. J. Sizes up to 215 w are available.

Porcelain Enamel

A new booklet, describing many of the characteristics and applications for procelain enamel, white and colored, has been issued by the Porcelain Enamel Institute, 1010 Vermont Ave., N. W., Washington 5, D. C. It includes a pictorial description of how procelain enamel is made and applied to metal parts. The information given is of interest to engineers, designers and manufacturing and sales executives.

(*Continued on page 234*)

D.P.I. Vacuum Coating Units

MEETING today's rigid requirements of uniform, versatile, high-capacity production.

The units pictured here are part of a large battery of the new D.P.I. Vacuum Coaters—Model LC 1-500-3, designed to deposit metals or metallic salts on glass, other metals, and plastics.

SIX OUTSTANDING FEATURES

1. Fast evacuation cycle
2. Convenient high-vacuum valve
3. Rugged construction
4. Low maintenance costs
5. Simplicity of operation
6. Completeness—ready for operation with the necessary pumps, gauges, controls, wiring, and service connections

For further information on D.P.I. vacuum coating equipment . . . *Write Vacuum Equipment Division.*

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Webster Electric Pickups are Precision-Built for Flawless Tone Reproduction

No radio-phonograph combination is better than its pickup—and no pickup ever built is better than the modern Webster Electric Pickup. That simple fact has led more and more manufacturers of fine quality instruments to standardize on crystal pickups and cartridges bearing the authentic Webster Electric name.

Webster Electric Pickups . . . delicate, sensitive, responsive to every tone shading and color range . . . are designed and built by an organization possessing vast experience in sound engineering and the manufacture of sound equipment. We are making every effort to supply the ever-increasing demand for Webster Electric Pickups and Cartridges as rapidly as possible.

We suggest that you permit us to consult with you with a view to determine the best application of our products as integral parts of your present or planned models. Write us direct—today.

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"Where Quality is a Responsibility and Fair Dealing an Obligation"

NEW BULLETINS

(Continued from page 233)

Commutator Stones

A new booklet on motor-generator maintenance and repair equipment has been issued by Ideal Commutator Dresser Co., Sycamore, Ill. A great deal of information is given about surfacing commutators and undercutting mica. The booklet also catalogs coil winding and armature winding machinery, growlers, insulation testers, blowers and vacuum cleaners and miscellaneous tools of interest to the electrical industry.

Research Index

A 72-page catalogue of the publications and patents which have resulted from fifteen years of fundamental and applied Battelle research has just been published by Battelle Memorial Institute, Columbus, Ohio.

Founded to advance education, science, and industry, through research and through the dissemination of technlogical information, Battelle has published widely in the nation's technical and scientific journals. The new catalogue lists more than eight-hundred such journal contributions, books, and patents between the years 1929-1944,, inclusive.

The catalogue includes subjects in the fields of organic chemistry, electrochemistry, chemical engineering, graphic arts, welding mineral dressing, industrial physics, technology, applied mechanics, ceramics, fuels, and metallurgy.

Contact Data

A new 36-page electrical contact catalog and data book (No. 12) issued by the Stackpole Carbon Co., St. Marys, Pa., contains information and data for manufacturers of products utilizing contacts. In addition to describing all of the many types of Stackpole contact materials with extensive notes on the applications of each type, the catalog gives data on such factors as variables in contact selection; factors in the choice of materials; contact types, shapes, and sizes; methods of attaching contacts; contact metal compositions; welding and brazing tips, and various others.

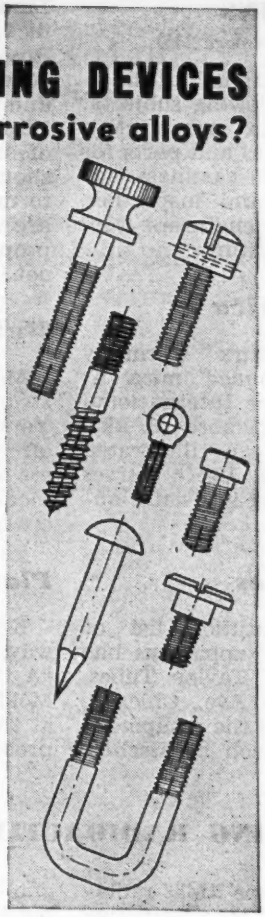
Die Casting

A valuable treatise on high-pressure die casting has been published by the H. L. Harvill Mfg. Co., Los Angeles, Calif., in cooperation with Paul R. Jordan, consultant of the same city. The book, of 100 pages,

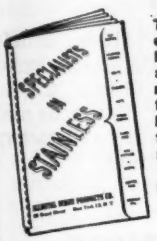
(Continued on page 236)

Do you need
SPECIAL FASTENING DEVICES
made of non-corrosive alloys?

DOES your production call for special fasteners made of non-corrosive alloys — screws, nuts, bolts or any other "made-to-order" fastening device? Allmetal has the "know-how" and facilities to make such specials accurately and economically, and to deliver them promptly. We have equipment for tapping, slotting, reaming, turning, drilling, threading, stamping, broaching and centerless grinding . . . and we work not only with stainless steel but with monel, everdur, duralumin, brass or any other non-corrosive alloys. Write, wire or 'phone for our quotation.



Send for FREE CATALOG



This new, 83-page catalog helps you select the correct size and type of non-corrosive fastening device for any particular job. Includes stock sizes, typical specials, engineering data, etc. Make request on company letterhead.

Write to Dept. D

ALLMETAL SCREW PRODUCTS CO.
80 Grand Street, New York 13, N. Y.

IMPORTANT RESISTOR DATA

These 12 pages of valuable resistor information are important to you! Here is complete data on Lectrohms wide selection of Vitreous Enameled Resistors; including fixed, adjustable, "Rib - on - edge" and ferrule terminal types—power line and R. F. chokes, brackets, bushings, solder pots, etc., with illustrations and complete description. If you do not have a copy —write for it!

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TEMPERATURE REGULATING STAND

A thermostatically controlled stand for regulating the temperature of an electric soldering iron when at rest. The thermostat is adjustable for various heats.

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Preferred by those who measure the value of a tool by the service it renders. Soldering irons are made in 5 sizes and for low as well as standard voltage.

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108-1

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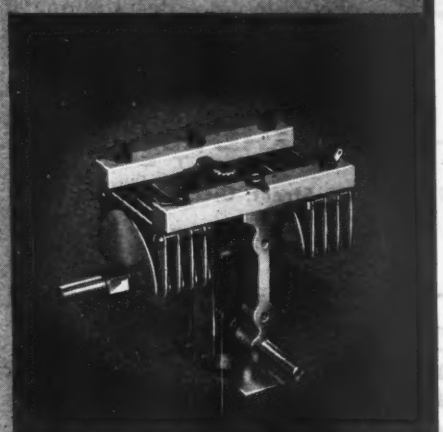


The 11000 Series Transmitting Condensers

Another Millen exclusive "Designed for Application" product. Illustrated is the 11035 size. Permits more efficient use of newer tubes—more compact and symmetrical circuit arrangements and consequent better neutralization. Center fed rotors for better high frequency current distribution. Isolantite insulation; terminals in convenient places. Sturdy cast aluminum center frame with right angle drive, 16/1 ratio. Rounded polished heavy gauge aluminum plates. Extended rotor shaft for dial or indexing device.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY

MALDEN

MASSACHUSETTS

NEW BULLETINS

(*Continued from page* 234)

with many photographs and drawings, covers the following subjects: Processes, materials, construction of dies, design of dies and parts for die casting, pressure castings, machining, finishing and inspection. It is written for engineers who wish to use die casting.

Glass Bonded Mica

Properties of Turx (formerly PemQue) glass bonded mica as manufactured by the International Products Corp., Baltimore 18, Md., are described in an illustrated booklet newly issued. Useful curves are included showing low water absorption.

Diathermy Tubes

A printed substitution list of tubes for diathermy apparatus has been published by Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill. The leaflet lists the equipment by manufacturer, such as Fischer, Lindquist, Bristow, Birtsher, Burdick, deForest, McIntosh, Majestic, Rose., etc., showing which type tubes are furnished with the unit and the Taylor tube substitute. With the extreme scarcity of tubes of original specification, the leaflet should prove an invaluable adjunct to many of whose diathermy units are standing idle for want of the proper vacuum tube, and who do not know of substitutes.

Multi-meters

Metropolitan Electronics & Instruments Co., 258 Broadway, New York 7, N. Y., has issued a folder offering multi-meters, signal tracers and resistance capacity bridges. Modern design and simplicity of operation are featured.

Plastic Molding

Kurz-Kasch, Inc., 1415 So. Broadway, Dayton 1, Ohio, have issued "A Businessman's Guide to the Molding of Plastics." Methods used at the factory to insure satisfactory products are explained.

MEASURING RADIOACTIVE EMANATIONS

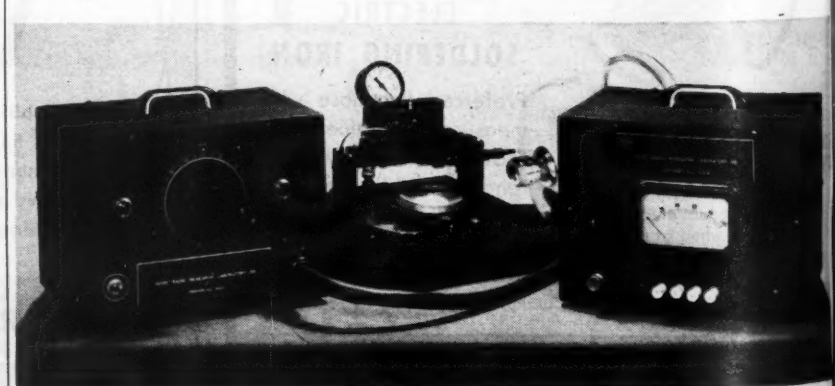
The Rowe radio type RM82 radioactivity "R" meter is a sensitive electronic apparatus for measuring directly very weak radiations from small quantities of radioactive materials. It will indicate values from 0.000001 to 20.0 "R" units. In spite of its very high sensitivity it is a fully stable instrument and is simple to operate.

The "R" meter is calibrated directly in fractions of "R" units on a linear scale of a four inch meter. It has five "R" ranges which are selected by push buttons. Full scales on these ranges at maximum voltage are: 0.0001, 0.001, 0.01, 0.1, and 1.0 "R" units. By using minimum voltage the least sensitive range can be extended to 20 "R" Units for full scale.

The meter proper is an electronic device which measures very small currents as low as 0.001 microampere. A high voltage power supply with adjustable output from 100 to 2000 volts dc is part of the apparatus Safety switches are provided so that there is no possibility of the operator being exposed to the high voltages.

Various types of units are provided for holding chemicals to be measured. The illustration shows one of several arrangements. In this case the material holder and electrodes are enclosed in a bell jar for evacuation. This is not necessary but often desirable.

The radioactivity "R" meter is enclosed in two steel cases, each approximately 11 in. wide, by 8 in. high, by 8 in. deep. The finish is a baked black enamel wrinkle. The apparatus is arranged for operation from 115 volts 60 cycle ac. Manufacturer is the Rowe Radio Research Laboratory Co., 2422 North Pulaski Road, Chicago 39, Ill.



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has a position open for Acoustical Engineer with experience in loudspeaker and phonograph record changer development or laboratory measurement. An attractive position for the man with experience. Wire or write for application:

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Desires position in charge of research and development. B.S. in E.E. and Ph.D. (electronic physics), age 39, married, 10 years in charge of research laboratory concerned with design and development of electronic devices; experience in telephone, power and electrical control development. Permanent position only, where initiative, ability and supervising talent required. Nature of undertaking, locale, etc. outweigh remuneration.

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An old established progressive radio parts manufacturer situated in southern California having national distribution requires a sales manager. Must have real executive ability. Several years experience in sales department of a radio parts manufacturing company or equivalent background essential. This is a splendid opportunity for a man capable of handling all contacts and correspondence with jobbers and manufacturers, supervising the activities of agents and salesmen and assisting in the design of new products, etc. Reply

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Formerly Senior Administrative Officer, Signal Corps Cost Analysis Agency

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EISLER EQUIPMENT
. . . the plus factor in tube manufacture

CHAS. EISLER specialized facilities are supplying high-efficiency manual, automatic and semi-automatic machinery for vacuum tube and electronic component production. Hundreds of devices are included — glass tube slicers, stem and sealing machines, flaring units, laboratory apparatus, etc.

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(B) No. 16 - 2S Two - Head Bench Type Flare Machine. Capable of rapid, efficient production. Simple operation.

(C) No. 23-12LD, new type 12 head giant Tipless Stem Machine.

(D) No. 11-TU Glass Tube Slicer, makes clean, sharp cuts—does not require skill.

(E) No. 57-X Laboratory Unit for glass cutting, flaring, stem making, sealing-in, exhausting, basing.

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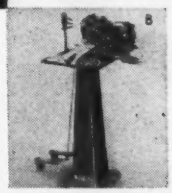

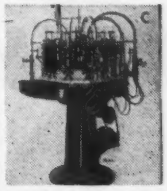

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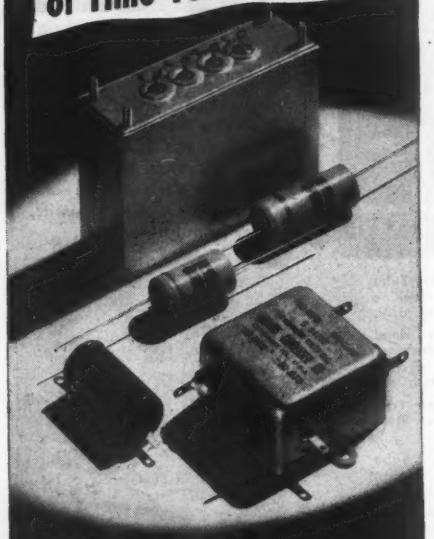
of Time-Tested Quality



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FM FREQUENCY ALLOCATIONS

Federal Communications Commission on Sept. 12 issued its list of frequencies which have been assigned to FM stations for operation in the new high frequency band. Following is the complete list:

METROPOLITAN STATIONS

City and Call Letters		Radiated Power kw	Antenna Height	Frequency
Baton Rouge, La.	WBRL	20	500	96.1
Binghampton	WNBF-FM	10.5	657	96.7
Boston	WBZ-FM	20	455	95.7
Chicago	WBBM-FM	10*	668	99.3
Chicago	WDLM	20*	479	99.7
Chicago	WEHS	12*	616	100.1
Chicago	WGNB	20*	472	98.9
Chicago	WWZR	12*	611	98.5
Columbus	WELD	20	341	94.5
Detroit	WENA	10.5	663	96.9
Detroit	WLOU	20	362	96.5
Evansville	WMLL	20	281	94.7
Fort Wayne	WOWO-FM	20	300	95.9
Hartford	WDRC-FM	7.0	758	94.3
Hartford	WTIC-FM	9.5	673	93.5
Indianapolis	WABW	20	290	94.9
Kansas City	KOZY	20	500	99.9
Kansas City	KMBC-FM	20	500	97.9
Milwaukee	WMFM	20*	310	92.3
Nashville	WSM-FM	8.5*	720	100.1
Philadelphia	KYW-FM	20	382	93.1
Philadelphia	WCAU-FM	20	366	95.5
Philadelphia	WFIL-FM	20	464	94.3
Philadelphia	WIP-FM	18	520	93.9
Philadelphia	WIBG-FM	20	358	95.1
Philadelphia	WPEN-FM	20	455	95.9
Pittsburgh	KDKA-FM	6.5	783	94.1
Pittsburgh	WTNT	20	500	94.5
Rochester	WHEF	20	387	98.5
Rochester	WHFM	20	261	98.9
Salt Lake City....	KSL-FM	8.5	720	100.1
Schenectady	WGFM	6	805	95.3
Schenectady	WBCA	6	805	95.7
South Bend	WSBF	20	312	101.3
Springfield, Mass.	WBZA-FM	20	500	99.1
Superior, Wisc...	WDUL	20	500	92.3
Worcester, Mass.	WTAG-FM	20	477	102.1
Worcester, Mass.	WGTR	9.5	680	101.7
Alpine, N. J.	WFMN	6.0	795	100.9
New York	WQXQ	11.5	632	100.5
New York	WABF	15	567	98.5
New York	WGYN	4.0	905	100.1
New York	WFGG	7.2	747	99.7
New York	WHNF	20	455	99.3
New York	WNYC-FM	15	560	98.1
New York	WBAM	15	559	96.9
New York	WABC-FM	5	850	97.3
New York	WEAF-FM	1.6	1258	97.7
Jersey City	WAAW	13.5	590	96.1

RURAL STATIONS

Mt. Washington, N. H.	WMTW	10		97.9
Winston-Salem, N. C.	WMIT	200		97.3

The following metropolitan stations may operate from their present sites with the power indicated below until such time as the Commission considers all of the applications in the Los Angeles area.

Los Angeles	KHJ-FM	4.8	870	99.7
Los Angeles	KTLO	4.8	870	100.1

**This antenna height is based upon previously authorized antenna construction, and a minimum antenna height of 500 feet above average elevation will be required in the future unless a showing is made to the contrary that such an antenna height is not feasible.*

Some Television Dollars and Cents

Several members of the staff of Electronic Industries have television sets which they are operating nightly to become thoroughly familiar with the technical and program problems of the new art.

One man has just completed a year's use of television in his own home, and now sums up his experiences. Similar reports could be made by other staff members as the result of their own experiences as members of the video audience. The year's report follows:

"Last evening being Saturday, with no television programs on the air, I went to a movie. For 75 cents I sat in a 'loge' seat, so far back that the entire screen could be totally hidden by a postage stamp held at normal reading distance, 12 inches from my eye (as determined by actual measurement there on the spot).

Video 16 times movie screen

"In other words, the movie picture, from where I sat, appeared to be no larger than one of Uncle Sam's gummed steel engravings pasted on a newspaper at ordinary reading distance for fine type. (In contrast, as I normally sit before my 9 x 12 in. home television screen, its size on by retina is just 16 times as large as was that movie screen from my 75-cent seat!)

"This movie experience—my first full cinema visit in many months—started me to figuring just how much it would have cost for movie tickets for all those evenings our home television set has been pouring forth its studio plays, news events, sports, westerns, educational films and variety acts.

$950 for shows!

"During the past year we have operated the television set at least 300 evenings or afternoons, with an average of two to three hours per day. The average audience has been five viewers. Had we bought that number of tickets (1,500) at, say 50 cents each, the year's outlay would have been $750.

"Our nearest cinemas are 4 miles away—8 miles, the round trip. To go by car would have entailed 2,400 miles of automobile travel, costing at least $200 more for gas and tires.

"So we have had television entertainment during the year that would have cost us $750 to $950 had we gone to the nearest movie. Also we saved three-quarters hour of travel time coming and going (225 hours per year) as well as inconvenience, and exposure to rain, snow and cold. Instead, with television we were able to enjoy ourselves relaxed in our own living room to the accompaniment of smokes, cool drinks, shoes off and minimum dress. And this is the kind of television enjoyment that is awaiting everyone in all of the 30,000,000 American homes that now have radios, and who eventually will be seeing as well as listening."